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**THE EFFECT OF SELF-REGULATED LEARNING
PROMPTS ON LEARNERS' PERFORMANCE IN A
SIMULATION LEARNING ENVIRONMENT**

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**Institute of Educational Technology
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**Master of Research (Educational Technology)
(MRes) Dissertation**

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Abstract

In this study, the effect of self-regulated learning (SRL) prompts on the academic performance of 30 key stage 3 science students learning with a computer-based simulation environment has been explored. Students were randomly assigned to either self-regulate learning (SRL) prompted or non-self-regulated learning (non-SRL) prompted condition. Mixed methods including pre and post self-regulatory skills questionnaires (SRSQ), pre and post reaction rates knowledge tests (RRKT), students' activity sheets (SAS) and class-room observation were employed for data collection and analysis. Students in the SRL prompted group were given activity sheets which contained self-regulated learning prompts whereas students in the non-SRL prompted group received no SRL-prompts in their activity sheets. It was discovered that the incorporation of SRL prompted instructions into a computer-based simulation environment that teaches the rates of chemical reactions facilitated shift in learners' academic performance more significantly than did the non-SRL-prompted condition. Data analysis indicated that this was associated with the presence of the SRL behavioural prompts in the activity sheets. The introduction of SRL-prompted instructions into a computer-based simulation learning environment assisted students to know what to do at the appropriate time during the given task. For science educational designers, this study establishes the platform to understand the application of SRL-prompted instructions to the teaching of different topics in a computer-based learning environment with a view to improving students' academic performance.

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Aims and Objectives

1.1: Introduction

This chapter presents the background and rationale for this study. Thereafter, research aims and objectives as well as the research questions are highlighted. In the last section of this chapter, I have presented the thesis outline.

1.2: The Background and Rationale for the Study

In the course of my twelve year science teaching career, I have reflected on how the role of a computer-based simulation learning environment in the teaching and learning of science by high school science teachers and students could be further advanced to deepen the understanding of a chemical concept such as rates of chemical reactions with the ultimate goal of improving the students' academic performance. A computer-based simulation learning environment for the teaching of chemical concepts has attracted my attention because it has the capacity to engage students as active participants and promotes motivational influence of authentic learning activities as well as student inquiry, thereby improving assessment of student progress. This interest has led me in search of the relevant published articles that address how a computer-based simulation learning environment improves science learners' academic performance. According to Chang *et al.* (2003) and Azevedo & Cromley (2004), the need for successful learning in a simulation learning environment that improves learners' academic performance poses a challenge which stipulates that learners on their own should manage and control their effort in order to attain the specified learning goals when using technological resources for inquiry and problem-based learning approaches. This implies that learners must choose what to

learn, how to learn, the time duration to be spent on learning, how to access relevant instructional materials, and to discern whether or not he or she comprehend the learning material with the aim of improving his or her academic performance. Furthermore, learning in a simulation learning environment demands that learners should analytically examine their learning contexts, identify relevant learning targets as well as the appropriate strategy they should employ, appraise the effectiveness of the adopted strategies in attaining the learning objective as well as their emerging understanding of the topic under consideration, modify their plans, goals, strategies, and effort in relation to the learning context (Pintrich 2000; Zimmerman 2000).

However, recent findings have revealed that learners might encounter problems in self-regulating their own learning in a simulation learning environment (Shapiro & Niederhauser, 2004; Azevedo 2005; Lajoie & Azevedo 2006). This consequently hinders their goals of improving their academic performance when learning challenging chemical concepts. One Possible solution to students' difficulty in regulating their own learning in a simulation learning environment is to investigate the impact of self-regulating learning prompts which assists students' learning in a computer-based simulation learning environment. It is hereby anticipated that the adoption of self-regulated learning prompts in a computer-based simulation learning environment might impact on the learner's conceptual understanding and lead to better academic performance. Therefore, the need to understand how a computer-based simulation learning environment employing self-regulated-learning prompts helps in improving key stage 3 science learners' performance will be chosen as the focus of this study.

1.3: Aims and Objectives of the Study

Self regulated learning prompts imply the provision of help to students to enable them use self regulated learning behaviours with a view to becoming active learners who are capable of managing their own learning in different contexts (Zimmerman 1989, Pintrich 2000). Therefore, this study aims to examine the degree of improvement and how a computer-based simulation learning environment with and without self-regulating learning prompts improves the learners' academic performance as a measure of conceptual understanding of the rates of chemical reaction (based on shift in academic performance from pre-test to post-test). Furthermore, this study investigates the nature of self-regulated learning strategies adopted by key stage 3 science learners' using a simulation learning environment with or without self-regulated learning prompts. Finally, the relationship between the science students' academic performance and the self-regulated learning strategies adopted by learners in a computer-based simulation learning environment shall be established. In this context, learning environment denotes a computer-based simulation learning environment that teaches the rates of chemical reaction with either a designed activity sheets having SRL or non-SRL prompts. Moreover, the science and the researcher were present in the classroom to guide the learners.

1.4: Research Questions

In order to investigate the effect of a computer-based simulation learning environment teaching the rate of chemical reactions with and without self-regulated learning prompts; on learners' performance, the following research questions shall be addressed by this study:

- (1) Does a computer-based simulation learning environment employed for teaching rate of chemical reactions leads to overall attainment of higher test scores?
- (2) Do different instructional conditions (a computer-based simulation learning environment with and without self-regulatory prompts) affect learners' conceptual understanding leading to greater academic performance?
- (3) How do different instructional conditions affect learners' ability to self-regulate their learning?

With regard to each of the research questions outlined in the above paragraph, I hypothesize as follows:

- (1) All learners, regardless of instructional conditions, would improve significantly from pre-test to post-test.
- (2a) A computer-based simulation learning environment with self-regulatory learning prompts would be associated with a statistically significant level of academic performance as compared to a computer-based simulation learning environment without self-regulatory learning prompts. Learners in the self-regulatory prompts group will have significantly higher scores on the reaction rates post-test.
- (2b) The computer-based simulation learning environment with self-regulatory learning prompts would be associated with a statistically significant level of academic improvement as compared to a computer-based simulation learning environment without self-regulatory learning prompt. Learners in the self-regulatory prompts group will have significantly higher scores on their activity sheets.
- (3) Students in the self-regulatory prompts group would use key self-regulatory processes (e.g. recalling previous knowledge) during learning due to self-regulatory prompt instructions more than the learners in the group without self-regulatory prompts.

1.5: Thesis Outline

This dissertation consists of six chapters. The first chapter presented the background and rationale for the research. The research aims and objectives as well as the questions that the research is set out to answer were presented in the same chapter. Chapter two starts with a brief summary of the literature review carried out. It then proceeds to describe the details of the literature review with the aim of providing a better picture into the past research work on how to be a self-regulated strategic learner in hyperspace as well as the effectiveness of computer-based simulation learning environments as learning tools in science education. Chapter three gives a description of the research methodology. This includes the rationale for the choice of methodology, instruments used for data collection and explain the research design implemented. Ethical considerations for the participants are also explained here. Chapter four presents the pertinent results of the investigation as well as the analysis along with justification for coding. Chapter five seeks to discuss, interpret and summarize the data presented in chapter 4. Chapter six reflects on the findings and limitations of this study. Recommendations are also given for future direction in the research on the effect of self-regulated learning prompts on the learners' performance in a computer-based simulation learning environment.

Chapter Two: Literature Review

2.1: Introduction

This chapter presents an overview of the effect of self-regulated learning (SRL) strategies on learners' performance when using a simulation learning environment. It begins with the identification of social cognitive theory as one of the models guiding self-regulated learning strategies. Social cognitive theory has been discussed according to propositions made by Bandura (1986) and I have related it to the self-regulated learning strategy. In order to locate this study within the framework and developing the rationale for it, I have critically examined studies that dwell on investigating the effect of self-regulated learning strategies on learners' performance in a computer-based simulation learning environment. Finally, the outcome of the literature search I have conducted has identified the need to understand how placing self-regulating learning prompts in a computer-based simulation learning environment that teaches rates of chemical reactions affects learners' academic performance.

2.2: Theoretical framework and model guiding self regulated learning in simulation learning environment

In the 1980s, theoretical frameworks and models guiding self-regulated learning (SRL) were proposed in an attempt to explain what it entails for a learner to be successful with regard to the setting of learning targets in a given context (Zimmerman 1989). While most theorists concur that learners' thoughts, feelings, and actions, that are planned and cyclically adapted to the attainment of personal goals, have interrelated cognitive, affective, motivational and behavioural dimensions

(Ziedner *et al.* 2000); dissenting opinions among theorists have been noted with regard to which dimensions ought to be emphasised; and consequently; what strategies and processes they tend to encourage learners to adopt in order to enhance learners' academic performance. Among the theories and models of self-regulated learning strategies already developed are the operant models, information processing and social cognitive models. According to Mace *et al.* (2001), Operant models of SRL are founded on the principle that self-regulated learning and behaviour emanate from the strategic manipulation by external stimuli and the consequences spontaneously follow an action. Operant models involve self-application of reinforcement strategies which allows students to set target behavioural goals that will lead to higher academic attainment, systematically observe, record, and evaluate progress, and adapt rewards towards reaching learning goals (Mace *et al.* 2001). Information processing models of SRL emphasise the use of metacognitive strategies such as self-monitoring and self-evaluation to carry out complex academic tasks (Winne 2001). Information-processing theories focus on covert rather than overt processes. Moreover, it considers motivational influences on whether a learner will use a particular learning strategy. In summary, information-processing theories do not consider social or environmental factors that may affect metacognition and academic achievement. Social cognitive models of SRL is distinguished from other models in that it investigates interrelationship among self-regulated learning strategies, beliefs, feelings and social and physical environment. (Bandura 1986, Zimmerman 2000,). For the purpose of this research, I will be considering Bandura's social cognitive theory of SRL as a comprehensive theoretical framework to conceptualize the effect of self regulated learning strategies on learners' performance in a simulation learning environment. Bandura's social cognitive theory suggests that SRL is context dependent, that is, the unique features of a learning environment may influence

whether or not a learner enacts SRL strategies. Therefore, using this theory as a guiding framework for this study will allow me to examine the interaction between learners' personal characteristics (e.g. cognitive, motivation), elements of the computer-based simulation learning environment and mediating self-regulatory processes that learners adopt (e.g. planning, monitoring activities).

2.2 1: Social Cognitive Theory (SCT)

Bandura's (1986) social cognitive theory highlights how personal, behavioural, and environmental factors affect learners' thoughts when faced with instructional choices. This he refers to as learners' ability to manage their behavioural responses in a learning environment. Figure 2.1 below has been adapted from Bandura's 1986 socio cognitive theory. It explains the social cognitive model as applied to the self-regulated learning employed in this study. Some of the personal characteristics of students learning in computer-based simulation learning include an affective factor (e.g. 'how do I feel about this task?') and self-efficacy (e.g. 'can I do the task?').

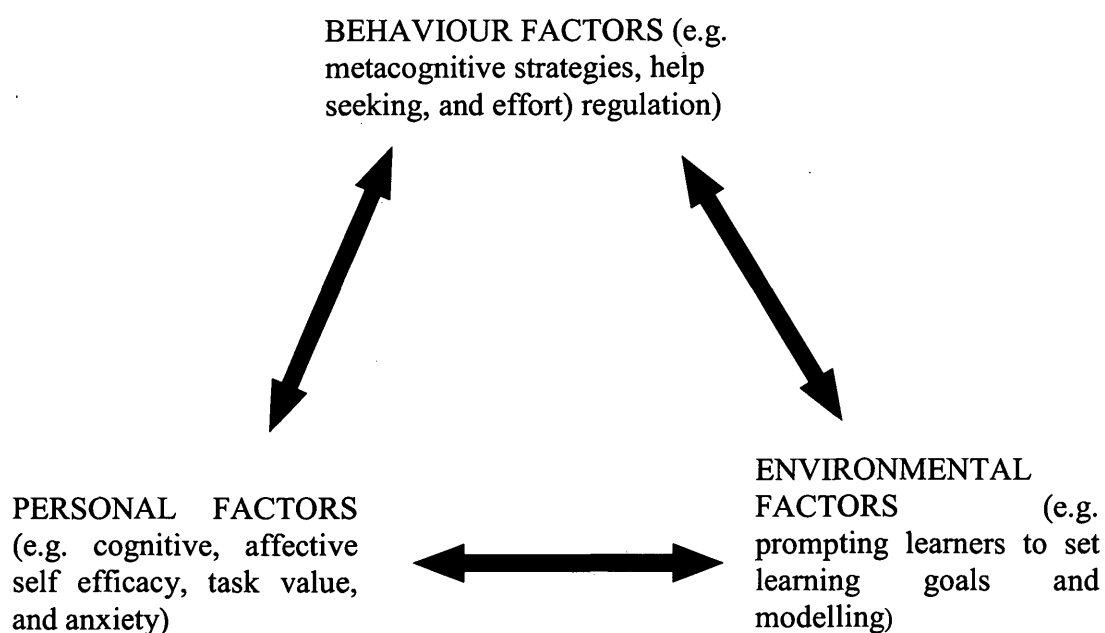


Figure 2.1: Bandura's social cognitive model adapted for learning in a computer-based simulation learning environment.

The behavioural factors influencing students learning in a computer-based simulation learning environment are the use of proper metacognitive learning strategies (e.g. planning task, monitoring their learning), effort regulation and help seeking behaviour. Research has shown that the use of metacognitive strategies has positive effects on students' academic performance (Pressley 1986; Pintrich 2000). Environmental influences entail helping students to monitor their learning, setting learning goals, and behavioural modelling. Pintrich & Schunk (2002) found that students were capable of learning complex skills through observing modelled performances. Therefore, modelling the effects of self regulated learning prompts on the students' academic performance and how they self-regulate their learning when studying about the rates of chemical reaction in a computer-based simulation learning environment will be considered as an important source of environmental influence in this study.

In the social cognitive theory as explained in Figure 2.1 above, the interaction between the person and behaviour involves the influences of a person's thoughts and actions. The interaction between the person and the environment involves human beliefs and cognitive competencies that are developed and modified by social influences and structures within the environment. The third interaction, between the environment and behaviour, involves a person's behaviour determining the aspects of their environment and in turn their behaviour is modified by that environment. Zimmerman (1989) is of the opinion that learners are not just being controlled by external factors but rather they possess self-directed capabilities to influence their own behavioural responses in a learning environment. This implies that learners have the ability to control their activities by applying cognitive, meta-cognitive, and

behavioural learning strategies when given learning tasks. In addition, Schunk (2001) explains that students' efforts to self-regulate during learning are not determined merely by personal processes such as cognition or affective issues; but rather, these processes are assumed to be influenced by environmental and behavioural events in a reciprocal manner. Bandura (1986) also shared a similar view that self-regulated learning occurs to the degree that a student can use personal processes to strategically regulate his or her behaviour and the immediate learning environment. Based on an adaptation of Bandura's theory to this particular context, I will hypothesize that students using a computer-based simulation learning environment are required to analyze the learning situation, set meaningful learning goals, and determine which strategies are effective as well as evaluating their emerging understanding of the topic they are studying. This is because the challenges being faced by self-regulated learners in a computer-based simulation learning environment do vary from those encountered by learners in the conventional face-to-face classroom. These challenges are in terms of the extensive amount of information available as well as the attractive but irrelevant material contained in the computer-based simulation learning environment. Learners also need to monitor their understanding and modify their plans, goals, strategies and effort in relation to task conditions (e.g. cognitive, and motivational) that are contextualised in a particular learning situation (e.g. learning factors concerned with the study of rates of chemical reactions in a computer-based simulation learning environment). This present study examines self-regulated learning from the social cognitive perspective in which the introduction of SRL instructional prompts into a social environment (a computer-based simulation learning environment) is assumed to influence the students' self-regulatory processes and their academic progress.

2.2.2: Self-regulated learning model

Consideration given to self-regulated learning framework from a contextual perspective arises partly from the changes undergone in learning theory and partly from the evolving learning contexts, which are designed to implement the learning theories in educational practice. From the social cognitive theorists' angle, the model of self-regulated learning proposed by Zimmerman (1989) states that "students can be described as self-regulated to the degree that they are metacognitively, motivationally and behaviourally active participants in their own learning process". According to Zimmerman, self regulated learners systematically use metacognitive, motivational and behavioural strategies to achieve academic goals. Moreover, self-regulated learners are regarded as active learners who are capable of managing their own learning in different contexts. In other words, self-regulated learning is an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and learning preferences in the context of those goals (Pintrich 2000). This description is similar to what Zimmerman (2000) describes as a "Triadic model of SRL" which involves the interaction of personal self-regulation of cognitive and affective states, behavioural self-regulation through strategic adjustment of performance as well as environmental self-regulation which involves the observation and adjustment of environmental conditions. While variations exist among the social cognitive theorist on conception of SRL, most of them suggest an iterative process in which a self-regulated learner establishes a desired learning goal, monitors progress, and regulates cognitive, behavioural, and environmental conditions to optimize learning.

Self-regulated learning is a significant concept in educational and psychological research which has been employed as a general construct to elucidate several areas of

human functioning such as learners' abilities to plan, monitor, set learning goals as well as evaluate the learning process (Bandura 1986). Research shows that once learners have acquired self-regulatory skills in using strategies, this will help them to promote their own learning and the perception of greater competence, which in turn sustains their motivation to attain new goals (Zimmerman & Martinez-Pons 1986, Pintrich 2000, Schunk & Zimmerman 2006). According to Zimmerman & Martinez-Pons (1986), learners who were high in their overall use of self-regulated strategies sought help more frequently from peers, teachers and parents and learned more than students who did not seek help. Learners' reported use of the self-regulated learning strategies (e.g. goal setting, monitoring, help seeking), have been shown to be highly correlated with various academic performance indicators such as the exam scores, grades and essays/reports (Zimmerman & Martinez-Pons 1988). They found that students' reports of using self-regulated strategies correlated with teachers' judgments of students' self-regulation behaviour during the class.

However, Zimmerman & Martinez-Pons study took place in the conventional classroom setting and not in a simulation learning environment. Research has shown that the challenges that self-regulated learners encounter in a computer-based learning environment differ from those in the conventional classroom. This might be associated with the large amount of information available as well as the attractive but irrelevant materials such as pictures, animations, contained in the computer-based learning environment. These challenges may result in learners' inability to control and regulate their learning activities effectively (Azevedo 2004, Shapiro & Niederhauser 2004, Azevedo 2005, Lajoie & Azevedo 2006). In order to overcome these challenges, various instructional interventions that could help learners to regulate their cognitive and metacognitive activities are necessary when engaged with

a simulation learning environment. Hence, this present study aims to investigate the effects of introducing self-regulated learning prompts in a computer-based simulation learning environment on the accomplishment of task performance.

Not surprisingly, several of the variables such as goal setting, monitoring, help seeking associated with self-regulated learning have been shown to have significant impact on the learners' performance in a computer-based learning environment. Previous studies on self-regulated learning have demonstrated that lack of effective metacognitive skills may lead to the ineffective use of instructional strategies and poor academic performance when learning in computer learning environment (Garhart & Hannafin 1986, Azevedo 2005, Narciss *et al.* 2007). Garhart & Hannafin (1986) indicated that learners were not aware of when they needed additional instructional support when learning in a computer based environment. Therefore, learners' inability to metacognitively monitor their learning may lead to their inability to make use of effective instructional support and this could make learners to be ineffective in regulating their learning. Narciss *et al.* (2007) examined how to promote meta-cognitive activities in a computer learning environment. The results of the study demonstrated a high variability in the total study time adopted by students; working with texts , learning tasks, elaborating tools for surfing, scanning, and trial-and-error-like exercise, and monitoring tools for fostering learners' active information processing in a learning environment; with some spending only a few minutes, while others spent 7 hour with the learning environment. Further analysis of their finding showed that averagely, students spent 70 % of their study time on text material, 15 % with learning tasks, and 13% with elaborating tools, whereas monitoring tools were hardly used (< 1%), with only few students using it. Moreover, it was discovered that the more time students worked on learning tasks, the higher their performance with the students working less than 3 hour processing a significantly lower percentage of texts and tasks and achieving significantly

poorer scores. Meanwhile, the research did not explain why lots of students decided not to use elaborating and monitoring tools for their learning and even for the few students that used them, the reason was not clearly stated. Could individual use of self-regulated learning strategies determine the way each learner learns in a simulation learning environment? Are the students motivated to use monitoring tools? Therefore, due to the challenges above, I argue that successful learning with computer-based simulation learning environments would require learners to self-regulate their learning. Given the importance of self-regulated learning model when learning in a computer-based learning environment, the next thing will be to investigate the effectiveness of prompting students to use self-regulatory strategies with the goal of improving their academic performance. This present study, examines whether prompting students with SRL behaviour in a computer-based simulation learning environment will have any effect on their performance.

2.3: Computer simulations in science education

For the purpose of this study, I will define computer simulation as a representation of activities that users learn about through interaction with the computer software (Alessi & Trollip 2001). According to Blake & Scanlon (2007), simulations have been used in science education since the early 1970s, and research is still on-going on how best to use simulations in the teaching of science. Blake & Scanlon evaluated three examples of simulation software developed by the Open University. From their evaluations; they were able to develop a set of features that could make learning with simulation by the distance learners to be effective. Student support, multiple representations and tailorability were the suggested features that could be considered to enable the most effective use of simulations. Their conclusion was that the success of simulation as effective learning tools in science education is dependent on how simulations are used; this present study therefore seeks to

look at the effect of the usage of self-regulated learning prompts on learners' performance in a simulation learning environment.

Furthermore, de Jong & Joolingen (1998) analyzed several problems associated with scientific discovery learning and examined how computer simulations could be used to offer a form of instructional support to overcome problems such as hypotheses generation, difficulties in modifying the generated hypotheses to afford the data being gathered as well as drawing inferences based on variables that remain unchanged in the experiments. They emphasised that self-regulation of the discovery learning process is a key issue which separates successful learners from unsuccessful learners. Successful learners tend to follow a plan going through their experiments, while unsuccessful learners use a more random strategy. Reports on whether or not the use of simulation has improved learners' performances have been found to be contradictory (de Jong & Joolingen 1998). For example, Bangert-Drows *et al.* (1985) discovered that after exposing learners to a computer based simulation; their examination scores did not improve whereas, Rivers & Vockell (1987) and Grimes & Willey (1990) are of the opinion that a computer based simulation enhances learners' conceptual understanding, as indicated by their scores, when compared with learning from some form of expository instruction e.g. computer tutorial or classroom. Morris *et al.* (2002) examined the contribution of computer-based activities to students' understanding of statistics. Their findings revealed that computer-based learner activities that allowed students to manipulate the data contributed to students' understanding of measures of central tendency as confirmed by significant improvement from pre-test to post-test whereas computer-based activities of this kind was found not to have significantly contribute to students' understanding of correlation. They reported that students in the computer-based learning environment

that did not allow direct manipulation of data did not show significant improvement from the pre-test to post-test in both central tendency and correlation. Although, the study of Morris and co-investigators lent credence to the claim that computer-base learning activities that provide multiple representations involving direct manipulations of data are likely to be beneficial to learning, this present study goes further to examine the effect of prompting learners with self-regulated learning skills such as setting their learning goals and planning the given task within the allocated time on their academic performance.

Boo & Watson (2001) addressed the development over time of learners' understanding of the concept of rates of chemical reactions among upper high school students. Students' understandings of four key parts of two chemical reactions in solution were examined. The parts were: (1) the type of change predicted, (2) the overall energy change predicted, (3) how the process of change was conceived or imagined and (4) what the students conceived of as the driving force for the change or the students' explanation for why they thought the change took place. The study was based on the interview with students age 16-18 studying chemistry. The interview questions and the framework used for the analysis of the interview data were based on what they viewed as the scientifically acceptable explanation for student at that level. The result from the first part of the interview response showed that most students had an understanding of what the reactants and products are but for parts 2- to 4, a lot of their responses were categorized as incorrect. An examination of the alternative conceptions that students used therefore helped in understanding the problems that they were facing in their explanations. A model of conceptual change developed by Posner and co-investigators (1982) suggested the favourable conditions that promote successful conceptual change among science learners as follows: (a) students must be strongly dissatisfied with their existing conceptions, (b) the new concepts must be

intelligible, initially plausible, and be proved to be fruitful in explaining a wide range of phenomena. While part of the difficulty in understanding chemical reaction rests with the nature of chemistry itself (i.e. the abstract and complex structure of explanations of chemical change), it seems that these problems arise from the ways by which the concepts are usually taught without regard to what is known about students' learning (prior knowledge) and about the content structure of the domain. In order to investigate how to improve the conceptual understanding of science students on the rates of chemical reaction, this present study examines the effect of incorporating self-regulated learning prompts into a computer-based simulation learning environment that teaches rates of chemical reactions on the year 9 students' academic performance

2.4: Self-regulation in the simulated learning environment

Self-regulated models offer a comprehensive framework with which to examine how students learn in computer-based learning environment. Several researchers (Azevedo 2004, Shapiro & Niederhauser 2004, Azevedo 2005, Lajoie & Azevedo 2006) have begun to examine the role of students' ability to regulate their personal and behavioural aspects when learning in computer learning environment. The three main phases of self-regulation; planning, monitoring and evaluation are described to be consistent with the regulative processes that students engage in during inquiry learning (Njoo & de Jong 1993). Planning is a very important strategy that students should perform when learning with computer-based simulation learning environment. According to Zimmerman (2000), self-regulating students will set goals and sub-goals the first time they are introduced to the learning task which in turn help them to decide on specific outcome of the learning or performance. Once self-regulating students begin to carry out their strategic plans, they begin to monitor their

comprehension and task performance. Effective strategies for monitoring include self-questioning and elaboration which include note taking (Chi *et al.* 1994). Evaluation of learning processes involves any reflection on the quality of the students' planning or how well they execute their plans. Self-regulating students will try to evaluate their learning based on the goals they set for themselves at the beginning of the task which should include adequate prediction as well as very clear inferences.

Research has shown that when students engage in computer-based simulation learning environment, they perform very few of the self-regulatory activities discussed earlier on in the first paragraph (Narciss *et al.* 2007, Azevedo 2004). They often have badly constructed plans or they do not have plans at all. Most students determine what to do as they move on with the learning; they make ad-hoc plans rather than taking a systematic approach. Zimmerman (2000) described this method of self-regulation as generally being ineffective because they fail to provide the necessary goal structure and strategic plans for students to progress consistently, monitor as well as evaluating their learning effectively. Prompting students with self-regulated learning behaviours might help to overcome these planning, monitoring and evaluating problems when learning in a computer-based simulation learning environment.

This review of the available literature reveals that there are several outstanding issues related to self-regulated learning when using simulation learning environments which have not been addressed by educational researchers. To date, there seems to have been little research into how key stage 3 science learners, regulate their own learning in computer-based simulation learning environment with a view to improving their

conceptual understanding of scientific concepts. Therefore, this study is concerned with the question of how students regulate their learning in a computer-based simulation learning environment related to rates of chemical reaction, in an attempt to improve their academic performance. Will the introduction of self-regulated learning instructional prompts into computer-based simulation learning environment have any effect on students' performance? This present study examines the effect of prompting students using a rates of chemical reactions computer-based simulation learning environment with SRL behaviours such as "goal setting, time management" etc. on their learning performance as well as their usage of the SRL strategies.

2.5: Conclusion

This literature review has looked critically at studies currently dwelling on the effect of self-regulated learning strategies on learners' performance in a computer-based learning environment. While this literature review has provided a context for the current study, it has also established need for further research into the relationship that exist between learners' self regulated learning strategies and their performance in a simulation learning environment. The social cognitive theory of self-regulatory learning has been explained as guiding framework for the present study. I have also investigated the significance of simulations as effective learning tools in science education. Finally, I have discussed the need for self-regulated learning in computer-based simulation learning environment that teaches rates of chemical reactions.

Chapter Three: Methods of Data Collection

3.1: Introduction

This chapter focuses on the research design and methodology underlying the investigation conducted for this study. The chapter's purpose is to explain the rationale behind the methodology used followed by a description of the research design and the approach taken for analysing data. The steps that are taken to ensure data gathering and ethical consideration of the study are also outlined.

3.2: Rationale for the approach

This study adopted mixed methods approach. Mixed methods researches are those that combine the qualitative and quantitative approaches in the research methodology of a single or multiphase study (Tashakkori & Teddlie 1998). Moreover, in mixed studies, the researcher first conducts a qualitative phase of a study, then a quantitative phase or vice-versa (Creswell 1995). Using mixed methods approach in data collection and data analysis offer educational researchers a path toward deeper understanding of their experimental results. (Igo *et al.* 2008). A mixed methods study was thought to be the best method for carrying out this research rather than doing either qualitative or quantitative research because it enabled me to explore the impact of instructional material that has self-regulated learning prompts on learners' performance in a simulation learning environment. Furthermore, the adoption both quantitative data collection and analysis with qualitative data collection and analysis assisted me to obtain a richer account of the effect of self-regulated learning prompts on learners' performance in a simulation learning environment. Bird & Hammersley (1996) are of the opinion that the use of several methods to explore an issue greatly

increases the chances of accuracy. Therefore employing both qualitative and quantitative methodological tools for this study was expected to lead to more valid, reliable and diverse construction of realities.

3.3: Sampling

The sample of the study consisted of a class of 30 science students in year 9, key stage 3 at a high school in Milton Keynes. I was given permission to carry out the study in this particular class because they were studying chemical reaction rates at a time that was suitable for my data collection. Pre-tests were administered to all participants in order to establish their knowledge about chemical reaction rates and their Self-regulated Learning (SRL) skills levels. This was designed to determine whether there were real differences in these two measures for the two groups at the beginning of the activity. Moreover, preliminary enquiry from the participating teachers also corroborated that the topic had not been covered for the students.

3.4: Research design

In order to investigate the research questions outlined in section 1.4 of this dissertation, an experiment was set up which involved two versions of a computer-based simulation learning environment that taught rate of chemical reactions. The two versions of the computer-based simulation learning environment represented two varying conditions in which SRL-prompted instructions and non-SRL-prompted instructions were provided to the students in each computer-based simulation learning environment. An experimental approach in which participants were randomly assigned to computer-based simulation learning environments using SRL-prompted instructions and non-SRL-prompted instructions had been adopted because it

minimized the risk of extraneous variables that might have confounded the outcome of this study (Cohen & Manion, 1989).

The SRL-prompted instructions were expected to help students develop the understanding of their own strategies and procedures in learning about rate of chemical reactions in a computer-based simulation learning environment. Prompts used in the SRL-prompted context included “set three specific learning goals you would want to achieve after learning about rates of chemical reactions” and “if you need help, please ask” among many others (see section 4.2 for further details). In the non-SRL-prompted context, no SRL-prompted instructions were incorporated into the computer-based simulation learning environment. Instead they had general reminders about the task such as entering data in to tables, time expected to spend on the whole task etc.

The subjects, year 9 students studying science, were randomly assigned to one of the two learning conditions (SRL-prompted instructions and non-SRL-prompted instructions). Students in both learning groups completed the self-regulated strategy questionnaire (SRSQ) before they were exposed to the rate of reactions computer-based simulation learning environment. Thereafter, students in each learning group (SRL-prompted instructions and non-SRL-prompted instructions) were allowed to conduct experiments on the effect of variation in temperature, concentration, and activation energy on the rate of chemical reactions. After conducting the simulated experiments, students in both groups were expected to write down their observations and draw inferences about the effect of variation in temperature, concentration, and activation energy on the rate of chemical reactions by completing blank spaces and tables of results in their learning activity sheets.

Pre- and post- reaction rate knowledge tests (RRKT) were used to determine the level of prior knowledge of students about the rate of chemical reactions and evaluate the effect of SRL-prompted instructions on the students' academic performance respectively. The conduct of pre- and post-reaction rate knowledge tests facilitated controls for time-related threats to validity (Blaxter *et al.* 2006). Both pre- and post-reaction rate knowledge tests (RRKT) are similar in that they are identical in the level of difficulty and complexity to the computer-based simulation problems (see section 3.5.2 for details). For the qualitative aspect of the study, students' activity sheets were scored on the basis of note taking, effort regulation, and task completion. Moreover, participants in each group were observed as they learnt in their respective learning context with the computer-based simulation learning environment teaching rate of reactions. I undertook a participant observer-role in which I was involved in the classroom at helping students if they request for help and made field notes during and after the lesson. Patton (1987) stated that field notes are the description of what was observed during the field work, therefore, the participant observation allowed me to identify the students' behaviour and their interaction patterns with the computer-based simulation learning environment as against using a non-participant observation approach. The observations however, were coded according to the emerging categories of how students made use of SRL skills when learning in the rate of chemical reactions simulation learning environment.

3.5: Instruments of data collection

In order to understand the effect of SRL-prompted on the academic performance of year 9 students using computer-based simulation learning environment to study rate of chemical reactions, this section discusses the instruments used in collecting data

for the study. Self-Regulatory Strategies Questionnaire (SRSQ), pre-test and post-test for reaction rates knowledge test (RRKT), Students' Activity Sheets (SAS) and the observation of the participants as they learnt with the simulation program were all examined.

3.5.1: Self-Regulatory Strategies Questionnaire (SRSQ)

Participants taking part in the study completed the Self-Regulatory Strategies Questionnaire (SRSQ) (see Appendix B). The SRSQ, a sub-set of Motivated Strategies for Learning Questionnaire was adapted by Young (1997) from Pintrich and co-investigators (1993). This study employed SRSQ because it addressed the learners' use of cognitive and self-regulatory strategies and not the learners' motivational beliefs. The SRSQ consisted of 31 items detailing the cognitive learning strategy scales of: metacognitive self-regulation, time and study environment, effort regulation, peer learning and help seeking. The SRSQ had reasonably good construct validity, internal consistency, reliability, and predictive validity (Pintrich *et al.* 1993). For example, SRSQ consisted of statements like:

“When studying, I try to determine which concepts I don’t understand well”
and

“When I study, I set goals for myself in order to direct my activities in each study period.”

In order to measure self-regulatory learning strategies, students were instructed to respond to how true each statement is to them by using a seven-point Likert scale ranging from 1 (Not at all true of me) to 7 (Very true of me). The questionnaire items which had been previously used for college students was accepted to be suitable for key stage 3 science students.

3.5.2: Reaction Rates Knowledge Test (RRKT)

A 14 item paper-based (see Appendix C) test on the rates of reaction was used for this study. The format of the test was developed to reflect that used in the GCSE chemistry examination format that tested students on the rates of chemical reaction. These included short-answer questions, matching, and multiple-choice tasks. For each of the five short-answer questions, students were asked to state the likely effect of varying certain factors affecting the rates of chemical reaction on it. For the matching task, students were asked to match four statements with their corresponding statements that related to the rate of chemical reaction. For the last task, students were given five multiple choice questions.

3.5.3: Students' activity sheets

Two types of students' activity sheets were designed for the purpose of this research to collect data on students' interaction with the computer-based simulation learning environment. Activity sheets for the SRL-prompted group consisted of SRL instructional learning prompts (Appendix D) whereas the activity sheets for the non-SRL group contained no SRL prompts (Appendix E). Students in both SRL- and non-SRL-prompted groups reported their predictions, observations and inferences on the given tasks by filling in the gaps and the tables in the activity sheets. The students' activity sheets were collected after the lesson and the contents were analysed.

3.5.4: Observation of the Participants

The use of participant observation in this study provided valid basis for accurate description of what learners were doing instead of what they remembered or thought that they were doing. This approach was adopted in order to relate learners'

behaviour to the conditions dictated by the task, decrease difficulties such as bias in questionnaire completion and learners' constraints in elucidating cognitive processes that they use during task performance. According to Turner (1995), this approach is associated with measuring the process of task performance in students. In addition, informal interview were conducted with three students from each of SRL-prompted and non-SRL-prompted groups. This was undertaken to validate the findings from the observation.

3.6: Data Analysis techniques

The data collected were analysed using both quantitative and qualitative methods. The quantitative data analysis involved the learning contexts (a computer-based simulation learning environment with and without SRL instructions) as independent variables while reaction rates knowledge test (RRKT) scores dependent variable. Various t-tests analyses were used to examine the data collected. Students' scores in Self-Regulated Learning Strategies Questionnaire (SRSQ) administered before and after learning with computer-based simulation learning environment were computed and analysed using independent-samples t-test. This test ensured that there were no differences between the two groups in terms of their SRL behaviours at the beginning of the activity.

A t-test for repeated measures was used for the comparison of the means of pre and post reaction rates knowledge test (RRKT) scores for all students. This was employed to determine the effect of learning with computer-based simulation learning environment. In addition, an independent-samples t-test procedure compared the shift in the means of test scores for SRL-prompted and non- SRL-prompted groups. These tests of statistical significance helped in providing information regarding the possibility that the results happened just by chance and random error rather than their

occurrence due to some fundamental true relationship between the variables. If the results obtained from the analysis are statistically significant, then the researcher can conclude that they did not occur only by chance (Tashakkori & Teddlie 1998). The adoption of t-tests to evaluate the differences in means between the SRL-prompted and non-SRL-prompted groups was based on the fact that this study is using a relatively small sample. Theoretically, it has been established that the t-test can be used for small samples sizes provided the variables are normally distributed within each group and the variation of scores in the two groups is not reliably different as confirmed by sample K-S test (see Table G1 in the Appendix G). The equality of variances assumption was verified with the Levene's test. The results of all as the t tests met Levene's test condition.

Qualitative analysis approach included content analysis of the students' activity sheets and classroom observations. The content analysis involved using the students' activity sheet to categorize how they made use of self-regulated learning behaviours when learning with the computer-based simulation learning environment. The categorisation was based on the entries made by students in the blank spaces that were available in the two types of the activity sheets as well as whether they were able to complete the given task within the allocated time or not. The use of content analysis in this study was based on signs or observable indicators regarding SRL skills that student deployed when performing tasks in the computer-based simulation learning environment (see Appendix H). For example, some of the SRL indicators that were used to measure the students' performance were whether the students write more information in the available spaces on their activity sheets or not, whether they were able to manage their time effectively by completing the given task on time or not. Therefore, content analysis enabled me to describe and draw appropriate

inferences about the effect of self-regulated learning prompts on the students' performance as measured by their scores on the activity sheets. In order to establish whether or not the incorporation of the SRL prompts in the experimental group's learning materials actually have effect on the learning outcome; an independent sample t-test was conducted to compare the mean scores of the learners in each group. (SRL prompts and non SRL prompts group). Also, the classroom participants' observations were analysed through working with and organizing the data, breaking the data into manageable units, synthesizing the data in order to search for certain patterns, deciding on vital aspects and dissemination of the findings (Bogdan & Biklen 1998). Therefore, the existence, meanings, and the relationships of the words or concepts that were related to self-regulated learning were explored and noted down during the process of analysis (see Appendix I for detail analysis).

3.7: Ethical Considerations

In order to adhere to the requirements of the Open University's human participants and ethics committee establishing ethical principles (see the ethical approval in Appendix F) for research involving human participants, an information sheet explaining the research and the derivable benefits to the education community; and the consent forms explaining the rights of withdrawal were sent out to the participants and their parents before data collection. This procedure also adhered to British Educational Research Association's (BERA) guidelines. Moreover, a consent form was designed to obtain permission from the participants and their parents for the use of their personal data for the purpose of this research in accordance with the Data Protection Act which ensured full confidentiality that the data will be kept secured and used for the purpose of this research only. Data collected was protected under the

Open University regulations. On completion of my research, the raw data was anonymised or deleted depending on how suitable it was for further research.

3.8: Conclusion

In this chapter, justification had been provided for adoption of mixed approach in this study; the research design, instruments of data collection, and data analysis were described. Further, I had presented the detailed description of research design, instruments of data collection, data analysis, and ethical considerations used in this study. The subsequent analysis of data will lead to discussion on the effect of self-regulated learning strategies instructional prompts on learners' performance in a simulation learning environment that teaches rates of chemical reaction.

Chapter Four: Data Collection and Analysis

4.1: Introduction

This chapter presents how the study was carried out in a high school in Milton Keynes and the learning environment and the learning tasks designed for this study will be discussed. The coding used for the pre and post Reaction Rates Knowledge Test (RRKT) and the Students' Activity Sheets (SAS) will be described. Finally, I will report on my class-room observation how different learning contexts adopted by both experimental and (SRL-prompted) and control (Non-SRL-prompted) groups had influenced their learning outcome.

4.2: Simulation Learning Environment and Learning Task

A rate of chemical reactions simulation produced by Sunflower© for teaching in high schools in the UK was used for this study. Year 9 learners who had not been taught the topic of rate of chemical reactions previously participated in this study.

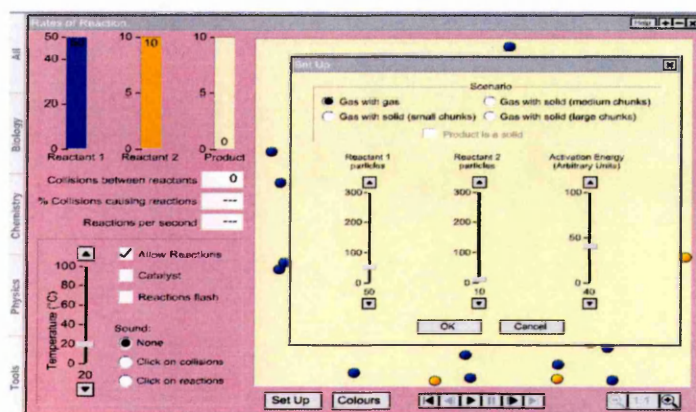


Figure 4.1: Rates of chemical reactions simulation.

Learning tasks took place during the second lesson period in one of the school computer suites which allowed all the students in both learning contexts to work individually on a rate of chemical reactions task in a simulation learning environment. Students worked through a computer simulation and expressed acquired understanding by writing on the space provided in the learning activity sheets. Two types of learning activity sheets were designed within the topic which enabled learners to discover the factors that affect the rate of chemical reactions. All the participating students were provided with an introductory material which explained what they were supposed to do. The researcher also read out the instructions to all the students before they started. The participating science teacher emphasised and made sure the learners comprehended what they were expected to do before they started.

The learning activity sheet was structured in such a way that students were initially asked to predict a task which aimed at activating their prior knowledge, observe the task through their engagement with the simulation and record their observation in the form of a laboratory report in the learning activity sheets. The learning activity sheets provided self-regulatory learning prompts for students in the SRL-prompted group which aimed to support them in managing their learning process. These SRL-prompts were in italicised texts, and based on the Self-Regulated Learning Strategies Questionnaire Manual (Pintrich *et al.* 1993). The SRL-prompts covered the metacognitive strategies that students used when learning with the computer-based simulation. For example, students were prompted to set three specific learning goals for themselves and plan how they would carry out each of the goal by allocating time to be spent on each goal. Other self-regulated learning behaviours that the SRL group students were prompted with were time management, effort regulation and help seeking behaviours. Students in the non-SRL-prompted group received an activity

sheet which contained no SRL-prompts but provided italicised reminders about the task, similar to the activity sheets given to the SRL-prompted group. The non-SRL-prompted group's activity sheets contained information about the overall time for the learning task and the tables for presenting their results. Students in both groups were provided with blank spaces in their activity sheets to make notes and write any questions that they would like to have answered.

4.3: Procedures for the Study

The research took place in a period of one week, in the summer of 2008, at a high school located in Milton Keynes, Buckinghamshire in the UK. Over the whole period of one week, three separate 50-minute lessons were used for each part of this research. The participants were tested individually in all learning contexts. During the first lesson, participants were randomly assigned to one of the two treatment groups; SRL-prompted instructional group (n =15) and the non-SRL-prompted instructional group (n =15). Thereafter, they were administered with the Self-Regulatory Skills Questionnaire SRSQ (see Appendix B). The administration of the SRSQ took 20 minutes. The researcher ensured that all participants completed the questionnaires before they were allowed to proceed to answer the pre-test. Next, the reaction rates knowledge pre-test (RRKT) (see Appendix C) was handed out during the same lesson and the students were given 20 minutes to complete it. Participants were expected to write their answers on the pre-test work sheets and were not given access to any instructional material at this stage.

During the second lesson, participants were taken through the simulation programme teaching the rates of chemical reaction. At the beginning of the lesson, the researcher

read out the instructions to the students in both experimental and control groups as follows:

“You are being presented with Sunflower multimedia learning environment which contains a simulation programme teaching rates of chemical reaction. The aim of this study is to learn about how key stage 3 science students use self-regulated learning strategies to learn in order to attain higher academic accomplishment when learning in a computer-based simulation learning environment teaching rates of chemical reaction. Your task is to learn all you can about the effect of concentration, activation energy, and temperature on the rates of chemical reaction and how they influence the particulate collision theory in 45 minutes.”

During the lessons, students in the experimental group (the SRL-prompted group) were given an activity sheet containing self-regulatory learning strategies instructional prompts (see Appendix D) whereas students in the control group (the non-SRL-prompted group) were given activities sheets that did not contain self-regulatory learning strategies instructional prompts (see Appendix E). The non-SRL-prompted group activity sheet still contained prompts that were reminders about the task. Students in the SRL-prompted group were provided with self-regulatory instructional prompts (see Appendix D) which facilitated their ability to achieve the following:

- (a) set specific learning goals,
- (b) recall previous related knowledge
- (c) plan their time and effort and monitor their progress towards goals.

(d) employ effective learning strategies like seeking for help, summarizing, hypothesising, and predicting.

The self-regulated learning strategy instructional prompts were designed on the empirical findings from literature on SRL and simulation learning environments (Azevedo and Cromley (2004); Azevedo *et al.* 2004a, b, 2005). The self-regulatory instructional prompts used the script developed by Azevedo, *et al.*, (2008) to assist students in the SRL-prompted group regulate their learning. Participants in both the experimental and control groups were observed as they learnt with the simulation during the lessons. The researcher recorded the participants' behaviours in the form of field notes. Reaction rates knowledge post-tests (RRKT) (see Appendix C) were administered during the first twenty minutes of the third lesson. Thereafter, SRSQ (see Appendix B) was administered again for twenty minutes.

4.4: Coding and scoring

4.4.1: Learning Outcomes

Learning outcomes that were assessed were the students' performances in the pre- and post-reaction rates knowledge test (RRKT) as well as their answers to the questions in the Students' Activity Sheets (SAS). Each of pre- and post RRKT carried a total of 14 marks. 1 mark was scored for a correct answer while no mark was awarded for wrong answers. For the Students' Activity Sheets (SAS), 1 mark was awarded for each correctly filled space and table, in all a total of 16 marks was obtainable from SAS. These marks were awarded based on the missing spaces that were common in the two groups' activity sheets. For example, spaces were provided in the activity sheets for the SRL-prompted group to write their learning goals,

planning activity, and prior knowledge of the topic. Non-SRL activity sheet on the contrary did not have spaces for these. Therefore marks were not awarded to both groups with regard to writing their learning goals, activity planning, and prior knowledge of the topic. Marks were awarded for the recording of observations, completion of the table in correct order, and correct explanation of the observations made on the two activity sheets.

4.4.2: Self-regulatory Behaviours

The analysis of students' use of self-regulated learning behaviour focused on their adoption of the regulative prompts. The SRSQ measured the students' SRL skills before and after learning with computer-based simulation. SRSQ scores were computed for each student by counting the number they choose on the Likert scale. The negatively worded items in the questionnaire were rated in reversed manner such that if a student who had circled 1 for that item now received a score of 7, and if they circled 2, received 6. The participants' self-regulated learning behaviours were also indicated by the way they responded during the lesson.

The students' activity sheets (SAS) were also used to assess the scope of how they had made use of SRL behaviours. This assessment was based on the common items in the two groups' activity sheets as pointed out in section 3.6. Students were classified on SRL skills' usage based on their monitoring behaviour through note taking in the activity sheets. Effort regulating skill was scored through the amount of information that they were able to put in the blank spaces while the time management skill was scored by counting the number of students that completed the task. Other SLR usages such as help seeking, goal setting are discussed using observation data.

4.5: Results

The results of the data analysis are hereby presented.

4.5.1 Students Pre-SRSQ scores

Table 4.1 (see details in Tables G2 and G3 in Appendix G) shows the mean scores of the SRSQ at the initial conditions for both the SRL-prompted group and non-SRL-prompted group. The t-test analysis revealed no statistically significant difference between the pre-SRSQ scores of the SRL-prompted group and non-SRL-prompted group $t(27.993) = 469, p > 0.05$. A significance value ($p = 0.642$) for the t-test attests to this fact.

Table 4.1: Means of Pre-SRSQ scores.

| Pre-SRL conditions | Mean (M) | Std. Deviation (SD) |
|------------------------|----------|---------------------|
| SRL -prompted group | 120.87 | 20.842 |
| Non-SRL-Prompted group | 117.27 | 21.168 |

This means that students were assigned into two groups irrespective of whether they have high or low level of SRL skills.

4.5.2: Students attainment in a simulation environment

The aim of this section is to determine whether or not the use of a computer-based simulation learning environment to help year 9 science students develop understanding of the rate of chemical reactions lead to their overall attainment of higher test scores?

Table 4.2: Means of the pre and post Reaction Rates Knowledge test scores for all participants.

| | Mean M) | Standard deviation (SD) |
|-----------|---------|-------------------------|
| Pre-RRKT | 6.37 | 2.930 |
| Post-RRKT | 10.67 | 2.551 |

The analysis of the t-test for repeated measure which compares the means of pre-test scores and post-test scores is presented in Table 4.2 (see details in Tables G4 and G5 in Appendix G) for all students irrespective of their group (SRL-prompted and non-SRL-prompted). This had been adopted with a view to determining whether all students, regardless of instructional conditions, improved significantly from pre-test scores to post-test scores. The analysis revealed that the hypothesis was supported by $t(29) = -8.545$, $p < 0.05$ significance value ($p = 0.000$) of the t-test for repeated measures indicates that there is a significant difference between the students' pre-test scores and post-test scores regardless of instructional conditions.

4.5.3: Effect of instructional conditions on students' attainment

4.5.3.1: Instructional conditions and students' attainment in pre and post Reaction Rates Knowledge test

Here, it is intended to determine if different instructional conditions (a computer-based simulation learning environment with and without self-regulatory prompts) affect learners' conceptual understanding leading to greater academic performance.

Table 4.3: Means and standard deviation of pre and post RRKT scores of SRL-prompted and non-SRL-prompted groups.

| | SRL Conditions | Mean(M) Difference in pre test and post test | Standard deviation (SD) |
|----------|------------------------|--|-------------------------|
| Pre-RRKT | SRL-prompted group | 6.87 | 3.137 |
| | Non-SRL-prompted group | 5.87 | 2.722 |

| | | | |
|------------|------------------------|-------|-------|
| Post -RRKT | SRL-prompted group | 12.27 | 1.534 |
| | Non-SRL-prompted group | 9.07 | 2.374 |

The independent-sample t-test for the means of pre and post RRKT scores presented in Table 4.3 (see details in Tables G10 and G11 of the Appendix G) found no significant differences between the SRL-prompted and non-SRL-prompted groups at the pretest, $t(28) = .933$ $P > 0.05$, but there were differences at post test, $t(28) = 4.384$, $p < 0.05$. The results indicate that there was improvement in the SRL-prompted group's performance at the post test.

Also, the analysis of the independent-samples t-test procedure which compares the shift in the means of test scores is presented in Table 4.4 (see details in Tables G6 and G7 in Appendix G) for SRL-prompted and non-SRL-prompted groups. This had been adopted

Table 4.4: Means and standard deviation of shift in the RRKT test scores of SRL-prompted and non-SRL-prompted groups.

| | Mean (M) Difference (pretest to posttest) | Standard Deviation (SD) |
|---------------------------|--|----------------------------|
| SRL-prompted group | 5.40 | 3.089 |
| Non-SRL-prompted group | 3.20 | 1.897 |

with a view to determining whether the use of the simulation learning environment with SRL-prompted activities was associated with a statistically significant level of shift in test scores as compared to the use of the simulation learning environment with non-SRL-prompted instructions. The analysis revealed that the hypothesis was supported by $t(28) = 2.350$, $p < 0.05$. A significance value ($p = 0.026$) for the t-test

indicates that there is a significant difference between the shift in the means of the test scores of the SRL-prompted group and non-SRL-prompted group.

A further analysis through the raw distribution of the students' test scores across the SRL-prompted and a non-SRL-prompted group at pre- and post-test provides detailed information about the categorisation of students' academic performance. Table 4.5 shows the frequency and percentage of students' RRKT scores categorised by the learning context. Students scores were categorised as follows: low test scores (0 to 6 marks), intermediate test scores (7 to 11 marks), and high test scores (12 to 14 marks).

Table 4.5: Frequency and percentage of students' RRKT scores categorised by the learning context.

| Learning contexts | Low test scores | Intermediate test scores | High test scores |
|-------------------|-----------------|--------------------------|------------------|
| Pre-RRKT | | | |
| SRL- prompted | 6 (40%) | 6 (40%) | 3 (20%) |
| Non-SRL-prompted | 6 (40%) | 7 (47%) | 2 (13%) |
| Post-RRTK | | | |
| SRL-prompted | 0 (0%) | 3 (20%) | 12 (80%) |
| Non-SRL-prompted | 2 (13) | 9 (60%) | 4 (27%) |

Meanwhile, Table 4.5 confirms that at pre-test, many learners in each of SRL-prompted and non-SRL-prompted groups could be categorised as having "low" and "intermediate" test scores, with a relatively low number of students achieving "high" test scores in each learning context. However, at post-test, the distribution of test scores for the SRL-prompted group varied noticeably from the pre-test, whereas, the distribution of academic performance varied slightly for the non-SRL group. For

example, at post-test, SRL prompted group had 12 students belonging to high test scores category compared to three learners categorised as high test scores at the pre-test.

Moreover, in the non-SRL context, only 4 learners attained high test scores at post-test, compared to 2 learners belonging to the same group at pre-test. Considering that there exists no difference in the distribution of test scores across the conditions at pre-test, it is hereby speculated that the introduction of the SRL-prompts might have had impact on students' academic performance as compared to a computer-based simulation with non-SRL-prompted instructions.

4.5.3.2: Instructional conditions and students' attainment in activity sheets

In order to determine the effect of the SRL prompts on the SRL-prompted group's activity sheets, an independent-sample t test was also employed to compare means for SRL-prompted group and non-SRL-prompted groups of students' scores in their activity sheets. The outcomes of the students' scores from activity sheets presented in Table 4.6 (see details in Tables G12 and G13 in Appendix G) were found to be statistically significant for the SRL -prompted groups $t(28) = 4.771, p<0.05$). This suggests that the SRL-prompted group produced better answers in their activity sheets.

Table 4.6: Means of the students' activity sheets' scores.

| Learning contexts | Mean(M) | Standard deviation(SD) |
|----------------------------|---------|------------------------|
| SRL Prompted (n=15) | 12.47 | 2.532 |
| Non-SRL-prompted (n=15) | 7.33 | 3.309 |

Again, the detailed analysis for the distribution of activity sheets scores were carried

out to support the initial test. Table 4.6 shows how the students’ activity sheets’ scores were distributed into three categories of low, intermediate and high scores. The total marks obtainable were 16 marks based on the blank spaces that were common in both groups’ activity sheets.

Table 4.7: Frequency and percentage of students’ activity sheets’ scores categorised by the learning context.

| Learning contexts | Low activity scores | Intermediate activity scores | High activity scores |
|-------------------|------------------------|------------------------------------|----------------------------|
| SRL prompted | (0%) | 9 (60%) | 6 (40%) |
| Non-SRL | 9 (60%) | 5 (33%) | 1 (7%) |

The distribution of activity sheets’ scores for the SRL-prompted group varied remarkably from that of non-SRL-prompted group. SRL prompted group had 6 students belonging to high score category compared to only one student categorised with high scores in the of non-SRL group. 9 students in the SRL- prompted group were found to belong to the intermediate category, while only 5 students from the non-SRL-prompted group could be classified as intermediate scorers. Interestingly, none of the students in the SRL-prompted group could be categorised into the low scores class while 9 students out of 15 fell into this group in the non-SRL group. Therefore, the distribution suggests that the introduction of SRL prompts into the instructional activity sheets could lead to greater understanding of the given task which might result in high academic performance.

4.5.4: Effect of Self-regulatory Activities on Learning Outcome

This section provides insight into how different instructional conditions affect learners’ ability to self-regulate their learning. It was hypothesised for this research

question that students exposed to SRL prompts in a simulation learning environment would use key self-regulatory processes during learning as a consequence of the self-regulatory prompts instructions whereas learners in the non-SRL-prompted group would not use key self-regulatory processes. The analysis revealed that the hypothesis was supported by $t(28) = 2.639, p < 0.05$. A significance value ($p = 0.012$) for the t-test indicates that there is a significant difference between the post SRSQ scores of the SRL-prompted group and non-SRL-prompted group.

Table 4.8: Means of Post SRSQ scores.

| Post-SRL conditions | Mean (M) | Std. Deviation (SD) |
|------------------------|----------|---------------------|
| SRL-prompted group | 141.60 | 20.952 |
| Non-SRL-prompted group | 119.47 | 24.816 |

Table 4.8 (see details in Table G2 and G3 in Appendix G) reveals that after the students had learnt with the computer-based simulation learning environment, the SRL-prompted group had some changes in their SRL skills as compared to the non-SRL-prompted group. Also, the independent-sample t-test for the shift in the means of the scores of preSRSQ to postSRSQ for the two groups presented in table 4.9,

Table 4. 9 :Means and standard deviation of shift in the SRSQ scores of SRL-prompted and non-SRL-prompted groups.

| | Mean (M) Difference (Pre SRSQ to Post SRSQ) | Standard Deviation (SD) |
|------------------------|---|-------------------------|
| SRL-prompted group | 20.73 | 16.1666 |
| Non-SRL-prompted group | 2.20 | 23.094 |

revealed that the hypothesis was supported by $t(28) = 2.546, P < 0.05$. A significant value of ($p = 0.017$) indicates that there is a significant difference between the shift in the mean of the test scores of the SRL-prompted group and non-SRL-prompted group.

Further content analysis of the students’ activity sheet (Table 4.8) reveals that the degree of usage of self-regulated learning strategies was greater among the SRL-prompted group than the non-SRL-prompted group.

Table 4.10: Percentages of specific types of responses to prompts by group.

| SRL Skills | SRL-prompted n=15 | Non-SRL n=15 |
|-------------------|-------------------|--------------|
| Note taking | 10(67%) | 5(33%) |
| Time management | 10(67%) | 2(13%) |
| Effort regulation | 11(73%) | 4(27%) |

For example, analysis of the monitoring SRL-skill by students as demonstrated by note taking shows that 10 out of 15 students (67%) among the SRL-prompted group filled in everything in their activity sheets while only 5 students (33%) did the same in the non-SRL-prompted group. With regard to task completion (time management skill), 10 (67%) students in the SRL-prompted group completed their activities on time, whereas only 2 (13%) students were able to do the same in the non-SRL-prompted group. In the SRL-prompted group, 11 (73%) students were able to carry out effort regulation whereas only 4 (27%) used this strategy in the non-SRL-prompted group.

4.5.5: Observational findings

Given the above results, I will now explore the research question of how different instructional contexts affected students’ ability to self-regulate their learning through the discussion of my notes and the informal interviews I had with the participating students.

The naturalistic observation allowed me to carry out further analysis to determine whether or not there were differences in the processes the learners from different instructional groups engaged in during their learning with the rate of chemical reactions simulation. I was particularly interested in examining the use of self-regulated learning strategies by the students across the different groups. In doing so, I observed the responses of the learners in the experimental group to the SRL-prompts in their activity sheets as against the general instructions given to the students in the non-SRL prompted group. In an attempt to analyse my field notes, (see Appendix I for the detail analysis of my observation) the question that kept coming to my mind was, were there any qualitative differences in the way learners learn from the simulation in their different instructional groups? Prompting the SRL students was intended to elicit different responses in the way they self-regulate their learning with the learning materials and determine whether this actually produces any difference in their academic performance as measured by the test scores. My observations of how learners behaved while learning were later grouped into three categories as follows:

The first category is what I will describe as students' understanding of the learning context. I observed that after reading out the general introduction to the students in both conditions, it was clear that all the students in the SRL-prompted group just picked up their pens to set sub-goals, as well as activating their prior knowledge of the topic, rate of chemical reactions. I noted that they actually read the prompts and responded through their actions. On the contrary, students in the non-SRL prompted group did not really settle down on the learning material in time. Moreover, some of the non-SRL-prompted students did not follow the instruction on the number of reactants that they should have on their screen, the colours to use for the reactants and

product. For example, students in the non-SRL group were having various colours of their choosing rather than following instructions.

The second category of behaviours I observed can be described as the level of task difficulty and demands. Students in the SRL-prompted group were able to control their learning context; they allocated time they would like to spend on each goal. I discovered that they made use of prompts on time and they still went ahead to confirm with me, how much time they had left. This showed that they were able to manage their time and put in effort into the learning. Students in the SRL-prompted group were reminded (in the activity sheet) to seek for help at anytime while learning, therefore, they were able to handle some of the difficulties they encountered while learning with the simulation by seeking help from the tutor or the researcher. In contrast, majority of the students in the non-SRL-prompted group just dealt with the task difficulty by playing round the simulation learning environment without requesting for help. Therefore, majority of the students in the non-SRL-prompted group did not manage their time effectively and did not complete their tasks on-time.

Another category that emerged from my observations was students' emotional-level. I noticed that students in the SRL-prompted group answered their questions and showed more interest in the learning. Moreover, they were very positive about the learning as a whole. A lot of students in the non-SRL-prompted group expressed some form of negative words of frustration and confusion. These feelings and lack of strategies to use when learning with the simulation might have contributed to their low performance in the learning outcome.

The outcomes of the informal interviews I had with the students from both groups in both are in agreement with my observational findings. For example a student in the SRL-prompted group when asked how she went about with learning from the computer-based simulation learning environment commented that he really enjoyed learning during the simulation lessons and task activities. He regarded the task activity to be better than writing a long report. He responded to all the prompts in the text boxes and found out that it was a good thing that he planned the whole activities right from the beginning of the lesson. He discovered that SRL-prompts enabled him to be time conscious, making sure that he completed the whole activities on time. He did report that he requested for help when he didn't know what to do when he was told to get the timer out from the tool bar. He commented that it was good that the teacher asked him to request for help which aided him in managing the allocated time efficiently.

For the learners in the non-SRL-prompted group, their comments were contrary to the one expressed above. A student in the non-SRL-prompted group said that she did not really enjoy the simulation lesson and task activities. She reported that she did not understand what to do on time. She found herself trying to find her way round whole simulation and before she knew it, the whole lesson had almost finished. On reporting her observations from the simulations in the activity sheets, she found this to be very boring. She wished her experience working with the simulations environment would have been different. She pointed out that she did not know how she could effect this change in her experience which she would have liked to do. Overall, she found this exercise to be a bit of a fun as she enjoyed watching the multi-coloured molecules colliding on the computer screen.

From these two responses above, it can be deduced that prompting students with SRL-behaviour will help them to plan how to carry out the giving task, monitor their own learning, seek for help, and manage effectively the allocated time for the given task. The implications of these findings will be presented in chapter five.

4.6: Conclusions

This chapter has presented how the study was carried out and the data collected were analyzed using methods thought to best answer the primary research questions. A mixed data analysis was employed in this study with the aim of understanding an individual in the learning context as well as to provide good, valid and reliable evidence to support the study's inferences and conceptual models. Various t tests analyses were used to examine these quantitative data. Descriptive statistics, such as, mean and standard deviations of students were calculated. The qualitative data in form of students activity sheets and the classroom observations were coded and the emerging categories were discussed. Despite the small sample size, the statistical tests for all the variables tested positive to normality distribution and assumption of variance. In agreement with Perry (2002), for the purpose of this self-regulation study, I had adopted self report measures to compliment other types of measures such as observation and interview with a view to providing deeper understanding into the study of self-regulation in the classroom. The overall results of this study indicated some degree of congruence among measures and this leads to a discussion about contextual dimensions of self-regulation and academic performance.

Chapter Five: Interpretation of the Data

5. 1: Introduction

This chapter intends to describe demonstrate how the data and its analysis used to support the research aims set out in section 1.3. The second part of this chapter summarises the outcomes of this study as described in section 4.5 and discusses its implications in the light of the overall research questions outlined in section 1.4 of this thesis. This chapter concludes by considering the implications of this study for the design of simulation learning environments.

5.2: Research Questions Revisited

Previous work in the field of self-regulated learning strategies had all been part of large studies whose main aims were to investigate learners' use of the self-regulated learning strategies as it affected their academic performance. Majority of these studies had taken place in the conventional class room settings (Zimmerman and Martinez-Pons 1988). Others that took place in the computer-based learning environment had looked at whether the learners made use of various meta-cognitive tools that were available in the learning environment or not (Narciss *et al.* 2007). This research goes further and looks into the effect of prompting students with SRL skills on their performance in a computer-based simulation learning environment. To answer the research questions in section 1.4, this section looks into how the data has shaped the answering of the three specific research questions.

5.2.1: Computer–Based Simulation Learning Environment and Academic Performance

The results presented in Table 4.2 showed that all students improved in their test scores after learning from the computer-based simulation learning environment. This lends credence to the hypothesis that all students irrespective of whether the simulation environment they were using for learning is supported by SRL-prompted or non-SRL-prompted instructions would gain some conceptual understanding when learning in a scientific simulation environment. This result agrees with the outcome from the work of Azevedo *et al.* (2005) whose work focussed on the use of a hypermedia learning environment to learn about the circulatory system in biology. Their research finding showed that students' learning about a challenging science topic with hypermedia irrespective of whether they are provided with support or not tends to gain a declarative knowledge from pre-test to post-tests. The finding by Azevedo *et al.* (2005) agrees with the result of this present study in the sense that all students who participated in this study gained some conceptual understanding of the rate of chemical reactions as measured by the overall knowledge test scores.

5.2.2: Differences Between Computer–Based Simulation Learning Environment with SRL- prompts and non SRL- prompts

This research investigated whether there are differences in the students' academic performances when learning with computer-based simulation learning environment with and without SRL prompts. The results of this study suggest that there is a statistically significant difference between the shift in the means of the RRKT test scores of the SRL-prompted group and non-SRL-prompted group. This is exemplified by the independent-samples t-test analysis which revealed that the hypothesis was

supported by a significance value ($p = 0.026$). This implies that there is a significant difference between the shift in the means of the test scores of the SRL-prompted group and non-SRL-prompted group. Also, the raw distribution of students' scores at post-test shows that SRL-prompted group had 12 students (80%) belonging to the high test scores category compared to 4 students (27%) belonging to the same category in the non SRL-prompted group (Table 4.4). Considering that only 3 (20%) and 2 (13%) students in SRL-prompted and non-SRL-prompted groups respectively belong to high test scores category at pre-test, it is hereby speculated that supporting students in a simulation learning environment with SRL-prompted instructions that enable them to make use of key SRL processes could lead to greater shifts in conceptual understanding as evident by the shift in means of test scores upon comparison of pre-test and post-test scores. This finding is supported by previous research outcomes which suggest that students who are provided SRL-prompted instructions display significant learning gains in different domains and scientific tasks (Chi *et al.* 1994 Azevedo *et al.* 2004b, 2005,). This outcome contributes to the literature on the usage of simulation learning environment in the teaching of chemical concepts by illustrating that SRL-prompted instructions aimed at facilitating students' ability to regulate their learning processes is associated with improved test score attainment during learning with simulation environment. In this study, a significant number of students in the non-SRL-prompted group displayed a shift in their test scores that could be categorised as intermediate academic performance in their conceptual understanding of the rate of chemical reactions. The results showed that students with low prior knowledge working in a simulation environment supported with non-SRL-prompted instructions might have inferior shifts in test scores as a measure of inferior gain in their conceptual understanding. This finding is in

agreement with other studies on computer learning environments supported with SRL-prompted instruction (Azevedo & Cromley 2004; Azevedo *et al.* 2004a).

Furthermore, students in the simulation learning environment with SRL-prompts were found to have attained higher marks in their activity sheets' scores than students in the non-SRL-prompted group (Table 4.5). The significant difference in the scores of students in both learning context implies that most students in the SRL-prompted group gave correct answers on their activity sheets while in non- SRL-prompted group, most students did not give correct answers. This might be associated with the presence of SRL-prompts on the SRL-prompted group's activity sheets. This finding suggests that supporting learners in the technology enhanced learning environment will have positive effect on the students' academic performance. (Njoo & De Jong 1993, Azevedo *et al.* 2004a). In summary, students in the SRL-prompted context were found to have outperformed students in the non-SRL-prompted group in both reaction rates knowledge test (RRKT) and students' activity sheets (SAS) scores.

5.2.3: Self-Regulation in a Computer–Based Simulation Learning

Environment with SRL- prompts and non SRL- prompts

This section provides insight into how different instructional conditions influence students' ability to self-regulate their learning behaviour. The t-test statistical analysis of the post-SRSQ scores confirmed that the SRL-prompted group had made use of SRL-skills; such as metacognitive strategies, effort management, help seeking and time management; to a greater degree than the non-SRL-prompted group (Table 4.7). Furthermore, it was found that students in the SRL-prompted group acquired more information as demonstrated by their specific types of responses to SRL-prompted instructions in their activity sheets (Table 4.8). These outcomes confirm that students in the SRL-prompted group were more likely to concentrate on important

information, generate more metacognitive activities, and construct a richer rational understanding of themes and purposes within the learning environment compared to students in the same learning environment supported with non-SRL-prompted instructions. Moreover, content analysis of the students' activity sheets suggests that not only did the students in SRL-prompted context demonstrated greater degree of qualitative shifts in their conceptual understanding and also displayed higher gains in several measures of scores awarded for correct filling of the blanks in the activity sheets (Tables 4.5 and 4.6), but they were found to have deployed the SRL-prompted instructions, to facilitate their own regulatory behaviour when learning in a simulation environment. This finding is supported by the results of the classroom observation and informal interview reported in section 4.5.5. Finally, Tables 4.7 and 4.8 provide support for the hypothesis that student in the SRL-prompted simulation learning environment made use of key SRL processes during learning as a consequence of the intervention occasioned by the introduction of SRL-prompted instructions. These results are in conformity with other studies that explored the deployment of SRL processes used by students interacting with technological learning environments (Azevedo & Cromley 2004, Azevedo *et al.* 2004a, 2004b, Lajoie & Azevedo 2006). The findings by these SRL researchers suggest that students who are not integrated into the learning environments (see the result of the non-SRL-prompted student interviewed in section 4.5.5) are at the risk of being unable to use SRL strategies effectively. Therefore, lower scores in the activity sheets obtained by students in the non-SRL-prompted group attest to this fact.

It is pertinent to note that the success of the incorporation of SRL-instructional-prompts into technological resources such as simulation learning environments for enhancing learning and self-regulation could be ascribed to the fact that the designed

SRL-prompts did not impose the burden of additional information processing that may interfere with the students' aim of concentrating on the to-be-learned information. Furthermore, because the designed SRL-prompted instructions were pedagogically integrated into the learning resources, it assisted the students to work towards achieving their target goals within the allocated time. Therefore, it is a surprise that the SRL-prompted instructions group was able to achieve instructional efficacy despite a brief exposure to prompts. The work of Young (1997) which adopted specific SRL-prompted instructions such as planning and monitoring in a learner-controlled and a program-controlled computer-based instruction (CBI) is in agreement with the findings of this study. On the other hand, the works of Graesser *et al.* (2007) which adopted the SEEK intervention to enhance global reasoning skill seemed not to have been successful as a consequence of the short intervention time frame during which the project must have been carried out. It is hereby speculated that the short-time frame incorporation of SRL-prompted instructions that addresses specific goals or activities, into a scientific simulation learning environment rather than broader interventions will be very effective in bringing about quickly changeable self-regulatory behaviours.

5.3: Conclusion

These findings from this study conform to the idea proposed by Njoo & de Jong (1993), de Jong & Joolingen 1998, Azevedo *et al.* (2004a, b), and Narciss *et al.* (2007) that technology-enhanced learning can be improved through the incorporation of SRL-instructional prompts into a technological environment. The outcomes of this research establish that the incorporation of SRL-prompted instructions into the scientific

simulation learning environment is able to deliver short-term intervention that improves academic performance and SRL skills' usage by year 9 science students.

Chapter Six: Conclusions and Recommendations

6.1: Introduction

This chapter aims to summarize the main findings of this study and further elucidate the implications of the findings from this study for theoretical and conceptual models of SRL and issues for classroom practice respectively. Finally, the limitations of this research and further recommendations for future studies are presented in section 6.5.

6.2: Key findings of the Study

This study explored the effect of SRL-prompts on students' academic attainment in the simulation learning environment that teaches the rate of chemical reactions. The results obtained from the data collected and its analysis demonstrated that the introduction of SRL-prompted instructions into a science simulation learning environment could be employed to improve students' understanding of difficult science topics. It was discovered that supporting key stage 3 science students learning in a simulation environment with SRL-prompted instructions, designed to teach about the rate of chemical reactions, could facilitate the use of key SRL processes and lead to statistically significant improvement in the attainment of higher test scores. This suggests an improvement in the students' understanding of the scientific concept, the rate of chemical reactions. The classroom observational studies carried out during this research provided the supporting evidence that students who had access to SRL-prompted instructions made use of key SRL processes and mechanisms that have been found to have ultimately resulted in significant shifts in the test scores and attainment of sophisticated conceptual understanding on other declarative knowledge

measures such as prior knowledge activation. Specifically, key findings of this study are as follows:

- (a) Students learning in a scientific simulation environment supported with SRL-instructional-prompts are likely to attain higher test scores than students in the same learning environment supported with non-SRL-prompted instructions
- (b) The introduction of SRL- prompted instructional activity sheets alongside the technological resources such as simulation learning environment enhanced learning in a variety of ways. Moreover, supporting students working in a scientific simulation learning environment was found to have promoted self-regulation.
- (c) This study establishes that the incorporation of SRL-prompted instructions into a scientific simulation learning environment has been effective in addressing specific goals or activities within a brief period of exposure.

6.3: Implications for theoretical and conceptual models of SRL

This study addresses concerns about current theoretical and methodological issues among SRL researchers with respect to studies concentrating on the understanding of the inter-relationship between SRL behaviours and learning environments employed during the cyclical and iterative of phases of planning, monitoring, time management and reflection (Njoo & De Jong 1993, Azevedo 2005). Buttler & Winne (1995) pointed out that a comprehensive model of SRL-prompted instructions incorporated in a technological learning environment would assist greatly in promoting theory-development and research that investigates the complexities of controlling the introduced scaffolds in a technological learning environment. Moreover, one of the major aims of this study is that using SRL prompts in computer-based simulation learning environment might help the students to take control of their own learning

through critical thinking which may lead to better academic performance. This study however, provides a platform for researchers to understand how the introduction of SRL-prompted instructions is applicable to the teaching of different topics in a computer-based learning environment.

6.4: Issues for classroom practice

It was noted that the introduction of SRL-prompted instructions in a scientific simulation learning environment has effectively supported the learning process very early in its intervention because students were more focused while learning with computer-based learning environment than without prompts. Providing students with SRL-prompts in computer-based simulation learning environment has kept students engaged as this was noted from my observational analysis because it assisted them to know what to do at the appropriate time during the given task. Furthermore, teachers using technology-enhanced learning environments should assist students in the appropriate selection of supports for task activities. For example, teacher might prompt students to use a particular strategy for the given learning task instead of just leaving students to wonder alone in the learning environment which might lead to their inability to complete the given task. The educational designers also need to be aware of the need for prompting students with self-regulated learning behaviour when learning in technology-enhanced learning environments; they could do this by placing the prompts next to the task activities and make clear how their use could benefit the learning outcomes.

6.5: Limitations and Recommendations

With regard to limitations of the study, students in the SRL-prompted group used SRL behaviours within the particular school context and specific computer-based simulation learning environment. The situational relevance of SRL to specific subject domain suggests that students who self-regulate on one occasion may be unable to self-regulate their studying on another occasion, thereby making SRL to be domain-transcending (Boekaerts 1995). Therefore, those group of students prompted with SRL behaviours may know how to self-regulate their learning in chemistry lesson but not for other subjects like history and mathematics. The fact that this study made use of a particular learning context poses limitations on the generalisability of the findings.

One of the limitations of the study was the small sample size (30) of the participating students. This was due to the difficulty that the research encountered in gaining access to the school used for this study. I would have preferred to conduct the experiment with additional classes in the same year as this would have enabled me to know whether other factors like learners' overall academic performance in the school will have any effect on the result of the findings. It may also be possible that my presence in the classroom during the completion of the SRSQ questionnaires could have biased all the students to have responded to the questionnaire. I think this might have impacted on the results obtained from the questionnaires rather than if they were allowed to take it home for completion and later on returned it to their school tutor.

Furthermore, a future study may employ an in-depth interview, rather than an informal one, with substantial number of participants from each learning context in which an audio or digital recorder will be utilized. This may enable the student to

express their expectations, feelings and give details of how they make use of SRL behaviours while learning in a computer-based simulation learning environment. Also the student academic records kept by the teacher could be used to strengthen the credibility of the study in the sense that the researcher will be sure of the students' ability as measured by their final grades. Besides, further studies should explore how the SRL prompts used in this study's activity sheets could be embedded into simulation learning environment which could come out in form of pop-up to inform a learner on what to do at a particular time while learning with simulation. Another area worth exploring for further study is the determination of the appropriate time to introduce the prompts when learning with the computer-based simulation learning environment.

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Appendices

Appendix A: Bibliography

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Appendix B: Self-Regulated Learning Strategies Questionnaire.

Name-----

The following questions ask about your study skills. There are no rights or wrong answers. Answer the questions about how you study as accurately as possible. If you think the statement is very true of you, circle 7; if a statement is not at all true of you, circle 1. If the statement is more or less true of you, find the number between 1 and 7 that best describes you.

- | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|-----------------------|---|---|---|---|---|-----------------|
| | | | | | | | Very True of Me |
| | Not at all True of me | | | | | | |
| (1) During the class, I often miss important points because I'm thinking of other things. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| (2) When reading for my lessons, I make up questions to help me focus my reading. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| (3) When I become confused about something I'm reading, I go back and try to figure it out. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| (4) If the lesson readings are difficult to understand, I change the way I read the material. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| (5) Before I study new lesson material thoroughly, I often skim it to see how it is organised. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| (6) I ask myself questions to make sure I understand the material I have been studying in the class. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| (7) I try to change the way I study in order to fit the requirements and the instructor's teaching style. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| (8) I often find that I have been reading but don't know what it was all about. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| (9) I try to think through a topic and decide what I am supposed to learn from it rather than just reading it over when studying. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| (10) When studying, I try to determine which concepts I don't understand well. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| (11) When I study, I set goals for myself in order to direct my activities in each study period. | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

- (12) If I get confused taking notes in class, I make sure I sort it out afterwards. 1 2 3 4 5 6 7
- (13) I usually study in a place where I can concentrate on my class work. 1 2 3 4 5 6 7
- (14) I make good use of my study time properly. 1 2 3 4 5 6 7
- (15) I find it hard to stick to a study schedule. 1 2 3 4 5 6 7
- (16) I have a regular place set aside for studying. 1 2 3 4 5 6 7
- (17) I make sure that I keep up with my weekly readings and assignments. 1 2 3 4 5 6 7
- (18) I attend my lessons regularly. 1 2 3 4 5 6 7
- (19) I often find that I don't spend very much time on my school work because of other activities. 1 2 3 4 5 6 7
- (20) I rarely find time to review my notes or readings before an exam. 1 2 3 4 5 6 7
- (21) I often feel so lazy or bored when I study that I quit before I finish what I planned to do. 1 2 3 4 5 6 7
- (22) I work hard to do well in the class even if I don't like what we are doing. 1 2 3 4 5 6 7
- (23) When class work is difficult, I either give up or only study the easy parts. 1 2 3 4 5 6 7
- (24) Even when lesson materials are dull and uninteresting, I manage to keep working until I finish. 1 2 3 4 5 6 7
- (25) When studying, I often try to explain the material to a classmate or friend. 1 2 3 4 5 6 7
- (26) I try to work with other students in my class to complete the class assignments. 1 2 3 4 5 6 7
- (27) When studying, I often set aside time to discuss the lesson material with a group of students from the class. 1 2 3 4 5 6 7
- (28) Even if I have trouble learning the material in the class, I try to do the work on my own, without help from anyone. 1 2 3 4 5 6 7
- (29) I ask the instructor to clarify concepts I don't understand well. 1 2 3 4 5 6 7

(30) When I can't understand the reading materials, 1 2 3 4 5 6 7
I ask another student in the class for help.

(31) I try to identify students in the class whom I can ask for 1 2 3 4 5 6 7
help if necessary

Appendix C: Test on Rates of Chemical Reaction

Name: _____

Instruction: This test consists of three sections. In the first section, you are to choose the correct answers from the given options by placing a tick in the box next to your chosen answer. In the second section, you will try to match the statement in the column A with that of column B. In the last section, you are expected to predict the likely effect of the factors affecting the rates of reaction in a chemical reaction.

Section 1

(1) Collision theory states that a chemical reaction can only take place when particles

- ☐ Collide
- ☐ Get hot
- ☐ Turn blue
- ☐ Get cold
- ☐ I don't know

(2) An increase in temperature

- ☐ Will turn particles positive Collide
- ☐ Will turn particles negative
- ☐ Will increase the rate of reaction
- ☐ Will decrease the rates of reaction
- ☐ I don't know

(3) For chemicals in solution, increasing the concentration will increase the rate of a reaction because

- ☐ The particles are stronger
- ☐ The particles are bigger
- ☐ The particles are smaller
- ☐ The particles are closer together
- ☐ I don't know

(4) The minimum amount of energy needed for colliding particles to react is called

- ☐ The rest mass
- ☐ The activation energy
- ☐ The activation mass
- ☐ The rest energy
- ☐ I don't know

(5) The rate of reaction increases as the temperature increases. Which of the following statements provides the best explanation for this?

- ☐ At lower temperatures the particles do not collide with each other

- ☐ At higher temperatures the particles have more energy, move faster and collide more often.
- ☐ Increasing the temperature increases the number of particles, so they collide more often
- ☐ Increase in temperature does not have any effect on the rate of chemical reactions.
- ☐ I don't know

Section 2

Match the statements on the right hand column (A) with the statements on the left hand column (B) by drawing lines between them.

| A | B |
|---|--|
| Increase in the concentration of a chemical reactant leads to | collide with sufficient energy that overcomes the activation energy. |
| The minimum amount of energy needed for a reaction to take place is | the average speed of all the particles is reduced. |
| Decrease in temperature of reactants means | more collision between the reactant particles |
| For a chemical reaction to happen, the reactant particles must | the activation energy |

Section C. : Predictive Tasks.

Please try and fill in the blanks in this section with short answers.

(a) If the temperature of reactant particles is increased, what happens to the average speed of the particles and the rates of chemical reaction?

(i) Average speed: _____

(ii) Rates of chemical reaction: _____

(b) If the activation energy of the reactant particles is increased, what happens to the rates of chemical reaction?

Rates of chemical reaction: _____

(c) If the concentration of reactants is reduced, what happens to the number of collisions between the particles and the rates of reaction?

(i) Number of collision: _____

(ii) Rates of chemical reaction: _____

Thank you.

Please return your test to Miss Bannis or Mrs Olakanmi

Appendix D: Students' activities A

Name-----

Introduction

You are being presented with a simulation learning environment that teaches rates of chemical reactions. You will learn how the rates of reactions depend on the frequency and energy of collisions between particles. You will also learn how the rates of reactions can be altered by varying temperature and concentration of reactants. You will also discover about the effect of varying activation energy, which is the minimum amount of energy needed for a reaction to occur, on the rates of chemical reactions.

Time allowed: 50 minutes

*Would you like to skim through
the whole activity before you
start?*

Aims of the lesson

- (1) To use the particulate model to explain changes in reaction rate.
- (2) To learn about how temperature and concentration affect the rate of a reaction.
- (3) To learn about how changes in activation energy affect the rate of reactions

Learning task

(1) Set three specific learning goals that you want to achieve after learning about rates of chemical reactions.

(a) _____

(b) _____

(c) _____

(2) Decide how much time you want to spend on achieving each goal.

Goal

*You can spend about 8
minutes on learning
tasks 1, 2 and 3*

(a) _____

Goal (b) _____

Goal (c) _____

(3) Can you write two things you already know about rates of chemical reactions please?



(a) _____


(b) _____

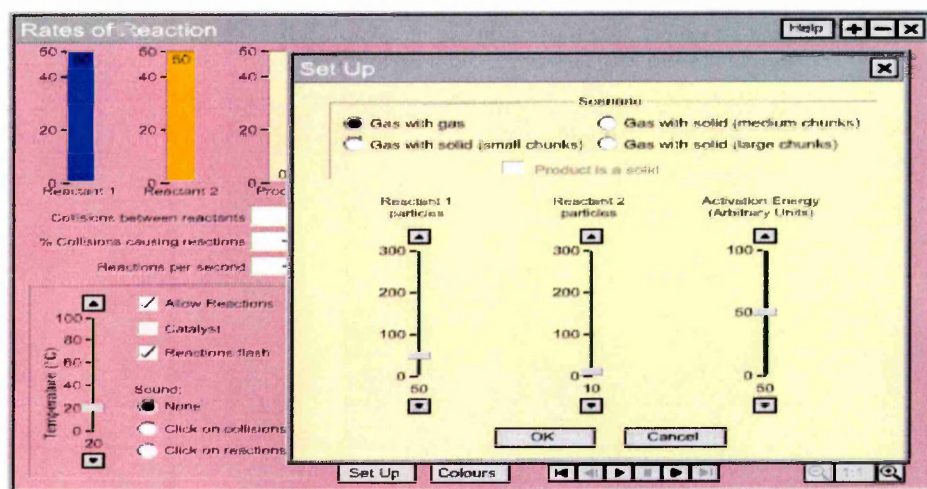
(4) Start the simulation by clicking on the Run new. The programme shows a simulation of two gases. The orange and blue particles are designated as reactants 1 and 2 respectively. They both react chemically together to form a product.


(5) Locate these buttons at the bottom of the simulation screen, (see the diagram below):



Use the 4th button  after the 'Colours' button to stop the simulation and the first button  to reset the simulation.

(6) Use the 'Setup' button  to set the programme to 50 blue (reactant 1) and 10 orange particles (reactant 2). Your screen will be similar to the one below.



(7) Select "Reactions flash" box and click on the play button  to start the simulation. Observe carefully how the particles are colliding together.

What do you think happens when there is a flash? _____ *Take note of the flash.*

Did you notice any change in the colour of the particles? _____

What was the colour change? _____

How many flashes did you notice? _____

Did you notice any collisions when there was no flash? _____

Therefore, we can say that for a reaction to occur the particles must collide with enough _____

(8) Now we need to take note of how long it will take for five reactions to occur at different concentration and temperature. Get the timer out by clicking on the tools

The screenshot displays the 'Rates of Reaction' software interface. The main window features a scatter plot with 'Temperature, °C' on the y-axis (ranging from 20 to 100) and 'Reaction rate, R' on the x-axis (ranging from 0 to 100). Three data series are plotted: Reactants 1 (blue squares), Reactants 2 (orange circles), and Reactants 3 (yellow triangles). All three series show a positive correlation between temperature and reaction rate. The interface includes a 'Rates of Reaction' title bar, a 'Help' button, and a 'Timer' window showing 03 h 00 m 03 s. The 'Rates of Reaction' window has a 'Reactants' section with three bars (Reactants 1, 2, and 3) and a 'Products' section with a bar (Product). The 'Reaction' section shows 'Reaction per second' and 'Reaction per second'.

_____ Please raise your hand
_____ if you need any help at
_____ any point during the
_____ activity.

| No. of Blue particles | 50 | 100 | 150 |
|--------------------------------------|----|-----|-----|
| Time for five reactions to occur (s) | | | |

(11) What do you think will be the effect of increase in temperature of reactants on the rates of chemical reaction?

(12) In this part, you will still use the same screen as above. Use the temperature slider to investigate the effect of temperature variation on the rate of change of particle movement and collision. Record how long it will take for five reaction products at 20°C to occur. Then repeat for 40°C and 60°C. Please keep the numbers of reactant 1 and 2 constant. Record your observations in Table 2 below.

Table C2: Effect of change in temperature on the rates of chemical reaction.

| Temperature (°C) | 20 | 40 | 60 |
|----------------------------|----|----|----|
| Time for five reactions(s) | | | |

If you need help please ask.


Explain your results:

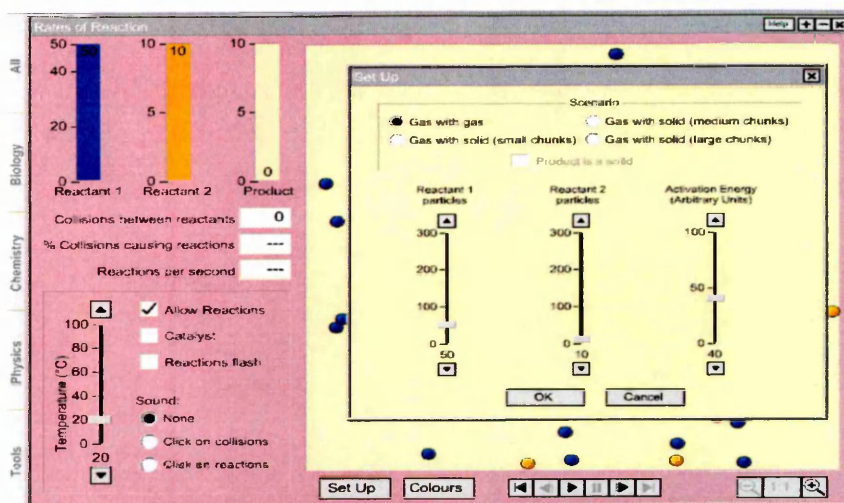
If you have any questions at this stage, please write them down in the space below.

(1) _____

(2) _____

(13) What do you think will happen to rates of chemical reaction if the activation energy is lowered?

(14) In this last part, you will use the simulation to investigate the effect of changing activation energy on the rate of reactions. Again, use the “Setup up” button  to set the number of particles for reactant 1 to 50 while that of reactant 2 is set to 10. Set the activation energy level to 40 and click OK. Your screen at this stage should look like the one below.




(15) Run the simulation by clicking on play button . Take note of the time spent for 10 reaction products to be formed. Then repeat for 50 and 60 levels of activation energy. Enter your results into Table 3 below

Table C3: Effect of changes in the activation energy of reactants on the rates of chemical reaction.

| Activation energy level | Time used for 10 reactions. |
|-------------------------|-----------------------------|
| 40 | |
| 50 | |
| 60 | |

Remember to raise your hand if you like help with anything please.

(16) What do you think is the role of activation energy in the rate of a chemical reaction.?

(17) Mention one factor that could help lower activation energy of a chemical reaction.

(18) _____

Are there any concepts that were not clear to you during the activity? Please write them here.

(1) _____

Appendix E: Students' activities B

Name-----

Introduction

You are being presented with a simulation learning environment that teaches rates of chemical reactions. You will learn how the rates of reactions depend on the frequency and energy of collisions between particles. You will also learn how the rates of reactions can be altered by varying temperature and concentration of reactants. You will also discover about the effect of varying activation energy, which is the minimum amount of energy needed for a reaction to occur, on the rates of chemical reactions.

Time allowed: 50 minutes

Don't forget to read the aims of this activity.




Aims of the lesson


- (1) To use the particulate model to explain changes in reaction rate.
- (2) To learn about how temperature and concentration affect the rate of a reaction.
- (3) To learn about how changes in activation energy affect the rate of reactions

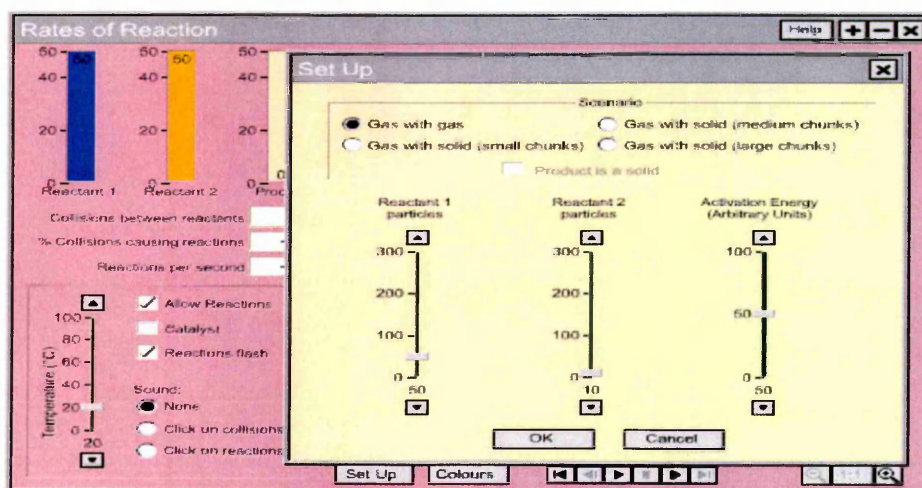
Learning task

(1) Start the simulation by clicking on the Run new. The programme shows a simulation of two gases. The orange and blue particles are designated as reactants 1 and 2 respectively. They both react chemically together to form a product.


(2) Try to look for these buttons below the simulation screen, (see the diagram below)

. Use the 4th button  after the colour button to stop the simulation and the first button  to reset the simulation.

(3) Use the 'Setup' button  to set the programme to 50 blue (reactant 1) and 10 orange particles (reactant 2). Your screen will be similar to the one below.



Click OK to close the Set Up screen

(4) Select “Reactions flash” box and click on the play button  to start the simulation. Observe carefully how the particles are colliding together.

What do you think happens when there is a flash? _____

Did you notice any change in the colour of the particles? _____

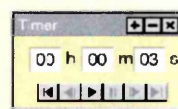
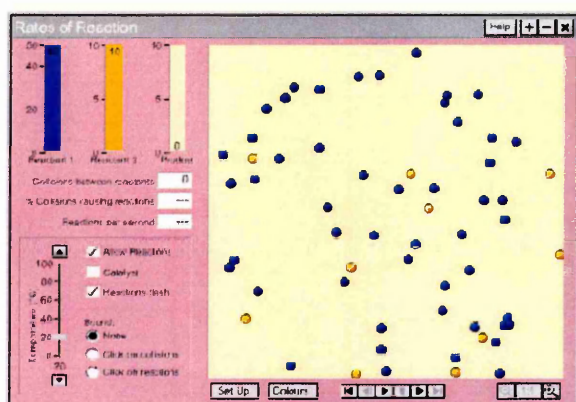
What was the colour change? _____

How many flashes did you notice? _____

Did you notice any collision when there was no flash? _____

Therefore, we can say that for a reaction to occur the particles must collide with enough _____

(5) Now we need to take note of how long it will take for five reactions to occur at different concentration and temperature. Get the timer out by clicking on the tools icons located by the left hand side tool bar and then click on timer from the list. Your screen will be similar to the one below



Please make use of the timer provided in the tools section.

(6) What do you think will be the effect of increase in concentration of reactant1 in the programme on the rates of chemical reaction?





(7) Use the ‘Setup’ button  to set the programme to 50 reactants 1 and 10 reactant 2 particles. Click on play button  to run the simulation and then on the timer’s play button  immediately. Use the product column next to reactant 1 and 2 to watch out for when five reaction products will be formed. Click on the timer’s stop button  and record the time taken for five reaction products to have formed in Table 1 below. Again, click on the ‘Set Up’ button and increase the number of reactant 1 particles to 100 and then record how long it takes for five products to have formed. Record your answer in Table 1. Repeat the same procedure with 150 reactant 1 particles and record the time for five reaction products to have formed.

Table D1: Effect of concentration of reactant 1 particles on the rates of chemical reaction.

| No. of Blue particles | 50 | 100 | 150 |
|--------------------------------------|----|-----|-----|
| Time for five reactions to occur (s) | | | |

The reaction is quickest with _____ number of blue particles.

(8) What do you think will be the effect of increase in temperature of reactants on the rates of chemical reaction?


(9) In this part, you will still use the same screen as above. Use the temperature slider to investigate the effect of temperature variation on the rate of change of particle movement and collision. Record how long it will take for five reaction products at 20°C to occur. Then repeat for 40°C and 60°C. Please keep the numbers of reactant 1 and 2 constant. Record your observations in Table 2 below.

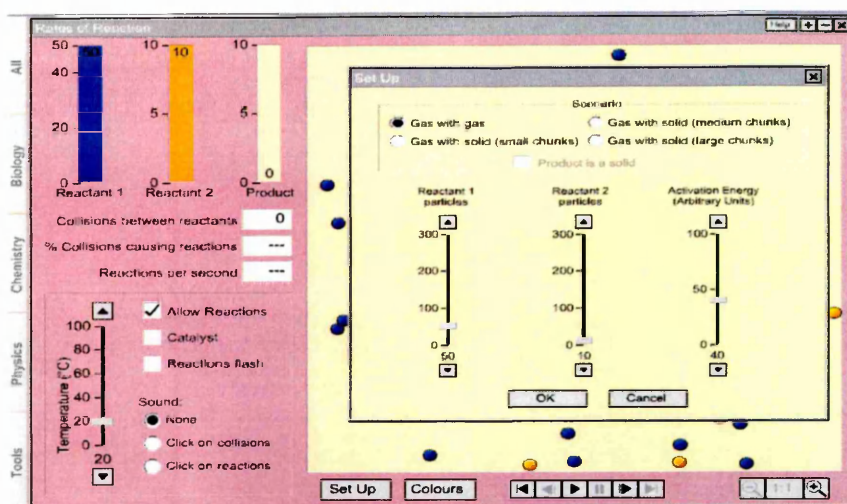
Table D2: Effect of change in temperature on the rates of chemical reaction.

| Temperature (°C) | 20 | 40 | 60 |
|----------------------------|----|----|----|
| Time for five reactions(s) | | | |

Explain your results:

(10) What do you think will happen to rates of chemical reaction if the activation energy is lowered?

(11) In this last part, you will use the simulation to investigate the effect of changing activation energy on the rate of reactions. Again, use the “Setup up” button  to set the number of particles for reactant 1 to 50 while that of reactant 2 is set to 10. Set the activation energy level to 40 and click OK. Your screen at this stage should look like the one below.




(12) Run the simulation by clicking on play button . Take note of the time spent for 10 reaction products to be formed. Then repeat for 50 and 60 levels of activation energy. Enter your results into Table 3 below

Table D3: Effect of changes in the activation energy of reactants on the rates of chemical reaction.

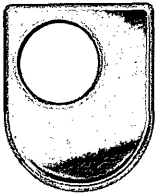
| Activation energy level | Time used for 10 reactions. |
|-------------------------|-----------------------------|
| 40 | |
| 50 | |
| 60 | |

Please record your observations on activation energy in this table.

(13) How will you explain the role of activation energy in the rates of chemical reaction.?

(14) Mention one factor that could help lower activation energy of a chemical reaction.

Appendix F: The Open University Ethical Approval



Memorandum

From John Oates
Chair, The Open University Human Participants and
Materials Research Ethics Committee
Research School
Email j.m.oates@open.ac.uk
Extension 52395

To Eunice Olakanmi, MRes Student, CREET

Subject **THE EFFECT OF SELF-REGULATED LEARNING
PROMPTS ON LEARNERS' PERFORMANCE IN A
SIMULATION LEARNING ENVIRONMENT**

Ref HPMEC/2008/#441/1
Date 24 June 2008

This memorandum is to confirm that the research ethics protocol for the above-named research project, as revised and submitted on 23/06/2008, is approved by the Open University Human Participants and Materials Ethics Committee by Chair's action. Please note that the HPMEC role in relation to research conducted by taught higher degree students is an advisory one and that the University assumes no liability in relation to such research.

John Oates
Chair, OU HPMEC

Appendix G: Statistical Analyses

Table G1: One-Sample Kolmogorov-Smirnov Test

| | Activities scores | K-pre total | K-post total | Shift | Pre-SRSQ | Post-SRSQ |
|--------------------------|-------------------|-------------|--------------|-------|----------|-----------|
| N | 30 | 30 | 30 | 30 | 30 | 30 |
| Normal Parameters (a, b) | Mean | 6.37 | 10.67 | 4.30 | 119.07 | 130.53 |
| | Std. dev. | 2.930 | 2.551 | 2.756 | 20.721 | 25.217 |
| Most Extreme Differences | Abs. | .113 | .220 | .143 | .170 | .101 |
| | Pos. | .113 | .143 | .143 | .170 | .096 |
| | Neg. | -.111 | -.220 | -.069 | -.119 | -.101 |
| Kolmogorov-Smirnov Z | | .618 | 1.204 | .785 | .931 | .554 |
| Asymp. Sig. (2-tailed) | | .839 | .110 | .569 | .351 | .918 |

a Test distribution is Normal.

b Calculated from data.

Table G2: Group Statistics for Pre-SRSQ and Post SRSQ

| | SRL conditions | N | Mean | Std. Deviation | Std. Error Mean |
|-----------|--------------------------|----|--------|----------------|--------------------|
| Pre-SRSQ | SRL- Prompted group | 15 | 120.87 | 20.842 | 5.382 |
| | SRL- Non -Prompted group | 15 | 117.27 | 21.168 | 5.465 |
| Post-SRSQ | SRL -Prompted group | 15 | 141.60 | 20.952 | 5.410 |
| | SRL- Non -Prompted group | 15 | 119.47 | 24.816 | 6.407 |

Table G3: Independent Samples Test for Pre-SRSQ and Post-SRSQ

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|-----------|---------------------------------------|---|-----------|------------------------------|--------|------------------------|---------------|------------|---|--------|
| | | F | Sig. . | t | df | Sig. (2- tailed) | Mean Diff. | S. E. D | 95% Confidence Interval of the Difference | |
| | | | | | | | | | Lower | Upper |
| Pre-SRSQ | Equal variance s assumed | .003 | .958 | .469 | 28 | .642 | 3.600 | 7.670 | - 12.112 | 19.312 |
| | Equal variance s not assumed | | | .469 | 27.993 | .642 | 3.600 | 7.670 | - 12.112 | 19.312 |
| Post-SRSQ | Equal variance s assumed | .719 | .404 | 2.639 | 28 | .013 | 22.133 | 8.386 | 4.956 | 39.311 |
| | Equal variance s not assumed | | | 2.639 | 27.234 | .014 | 22.133 | 8.386 | 4.934 | 39.333 |

Table G4: Group Statistics for shift in SRSQ

| SRL conditions | | N | Mean | Std. Deviation | Std. Error |
|----------------|-------------------------|----|-------|----------------|------------|
| ShiftSRSQ | SRL- Prompted group | 15 | 20.73 | 16.166 | 4.174 |
| | SRL- Non -Prompts group | 15 | 2.20 | 23.094 | 5.963 |

Table G5: Independent Samples Test for in SRSQ

| | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|------------|---|------|------------------------------|--------|-----------------|-----------------|-----------------------|---|--------|
| | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | Lower | Upper |
| ShiftSRS Q | 1.156 | .291 | 2.546 | 28 | .017 | 18.533 | 7.279 | 3.624 | 33.443 |
| | | | 2.546 | 25.064 | .017 | 18.533 | 7.279 | 3.545 | 33.522 |

Table G6: Paired Samples Statistics for RRKT

| | | Mean | N | Std. Dev. | Std. Error Mean |
|--------|-----------|-------|----|-----------|-----------------|
| Pair 1 | Pre -RRKT | 6.37 | 30 | 2.930 | .535 |
| | Post-RRKT | 10.67 | 30 | 2.551 | .466 |

Table G7: Paired Samples Test for RRKT

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|-------|----------------------|--------------------|-----------|-----------------|---|--------|--------|----|-----------------|
| | | Mean | Std. Dev. | Std. Error Mean | 95% Confidence Interval of the Difference | | | | |
| | | | | | Lower | Upper | | | |
| Pair1 | Pre-RRKT - Post-RRKT | - 4.300 | 2.756 | .503 | -5.329 | -3.271 | -8.545 | 29 | .000 |

Table G8: Group Statistics for shift in RRRKT

| | SRL conditions | N | Mean | Std. Deviation | Std. Error Mean |
|-------|--------------------------|----|------|----------------|-----------------|
| Shift | SRL -Prompted group | 15 | 5.40 | 3.089 | .798 |
| | SRL -Non -Prompted group | 15 | 3.20 | 1.897 | .490 |

Table G9: Independent Samples Test for shift in RRRKT

| | | Levene's Test for Equality of Variances | | | | | t-test for Equality of Means | | | | | | |
|-------|-----------------------------|---|------|-------|--------|-----------------|------------------------------|-----------------|---|----------|--|--|--|
| | | F | Sig. | T | df | Sig. (2-tailed) | Mean. Diff. | Std. Err. Diff. | 95% Confidence Interval of the Difference | | | | |
| | | | | | | | | | Low. Lim. | Up. Lim. | | | |
| Shift | Equal variances assumed | 3.711 | .064 | 2.350 | 28 | .026 | 2.200 | .936 | .283 | 4.117 | | | |
| | Equal variances not assumed | | | 2.350 | 23.247 | .028 | 2.200 | .936 | .265 | 4.135 | | | |

Table G10: Group Statistics for Pre-RRKT and Post RRKT

| | SRL conditions | N | Mean | Std. Deviation | Std. Error Mean |
|-----------|-----------------------|----|-------|----------------|-----------------|
| Pre RRKT | SRL Prompts group | 15 | 6.87 | 3.137 | .810 |
| | SRL Non Prompts group | 15 | 5.87 | 2.722 | .703 |
| Post RRKT | SRL Prompts group | 15 | 12.27 | 1.534 | .396 |
| | SRL Non Prompts group | 15 | 9.07 | 2.374 | .613 |

Table G11: Independent Samples Test for Pre-RRKT and Post-RRKT

| | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|-----------|---|------|------------------------------|--------|-----------------|-----------------|-----------------------|---|-------|
| | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference | |
| | | | | | | | | Lower | Upper |
| Pre RRKT | .288 | .596 | .933 | 28 | .359 | 1.000 | 1.072 | -1.197 | 3.197 |
| | | | | | | | | | |
| | | | .933 | 27.456 | .359 | 1.000 | 1.072 | -1.198 | 3.198 |
| | | | | | | | | | |
| Post RRKT | 1.885 | .181 | 4.384 | 28 | .000 | 3.200 | .730 | 1.705 | 4.695 |
| | | | | | | | | | |
| | | | 4.384 | 23.950 | .000 | 3.200 | .730 | 1.693 | 4.707 |
| | | | | | | | | | |

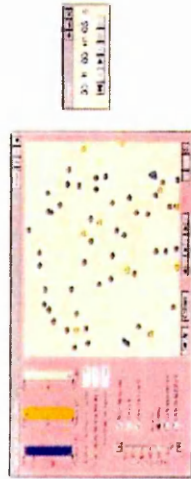
Table G12: Group Statistics for Students’ Activity Sheets

| | SRL conditions | N | Mean | Std. Deviation | Std. Error Mean |
|-------------------|-------------------------|----|-------|----------------|-----------------|
| Activities scores | SRL- Prompted –group | 15 | 12.47 | 2.532 | .654 |
| | Non-SRL- Prompted group | 15 | 7.33 | 3.309 | .854 |

Table G13: Independent Samples Test for Students’ Activity Sheets

| | | F | Sig. | T | df | Sig. (2-tailed) | Mean Diff. | S. E. D | 95% Confidence Interval of the Difference | |
|-------------------|-----------------------------|------|------|-------|--------|-----------------|------------|---------|---|-----------|
| | | | | | | | | | Low. Lim. | Upp. Lim. |
| Activities scores | Equal variances assumed | .812 | .375 | 4.771 | 28 | .000 | 5.133 | 1.076 | 2.930 | 7.337 |
| | Equal variances not assumed | | | 4.771 | 26.206 | .000 | 5.133 | 1.076 | 2.923 | 7.344 |

Appendix H: Content Analysis



(9) What do you think will be the effect of increasing the concentration of reactant 1 on the rates of chemical reaction?
The reaction time will be quicker. *Please raise your hand if you need any help any point during activity.*

(10) Use the 'Setup' button to set the programme to 50 reactant 1 and 10 reactant 2 particles. Click on play button to run the simulation and then on the timer's play button immediately. Use the product column next to reactant 1 and 2 to watch out for when five reaction products will be formed. Click on the timer's stop button and record the time taken for five reaction products to have formed in Table 1 below. Again, click on the 'Set Up' button and increase the number of reactant 1 particles to 100 and then record how long it takes for five products to have formed. Record your answer in Table 1. Repeat the same procedure with 150 reactant 1 particles and record the time taken for five reaction products to be formed.

Table 1: Effect of concentration of reactant 1 particles on the rates of chemical reaction.

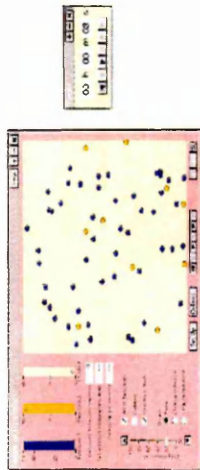
| No. of Blue particles | 50 | 100 | 150 |
|--------------------------------------|----|-----|-----|
| Time for five reactions to occur (s) | 5 | 2 | 0.5 |

The reaction is quickest with 150 number of blue particles.

(11) What do you think will be the effect of increase in temperature of reactants on the rates of chemical reaction?
The reaction will be quicker. *25 minutes at this stage.*

(12) In this part, you will still use the same screen as above. Use the temperature slider to investigate the effect of temperature variation on the rate of change of particle movement and

Appendix H1: SRL activity sheet 1



(9) What do you think will be the effect of increasing the concentration of reactant 1 on the rates of chemical reaction?
The reaction time will be quicker. *Please raise your hand if you need any help any point during activity.*

(10) Use the 'Setup' button to set the programme to 50 reactant 1 and 10 reactant 2 particles. Click on play button to run the simulation and then on the timer's play button immediately. Use the product column next to reactant 1 and 2 to watch out for when five reaction products will be formed. Click on the timer's stop button and record the time taken for five reaction products to have formed in Table 1 below. Again, click on the 'Set Up' button and increase the number of reactant 1 particles to 100 and then record how long it takes for five products to have formed. Record your answer in Table 1. Repeat the same procedure with 150 reactant 1 particles and record the time taken for five reaction products to be formed.

Table 1: Effect of concentration of reactant 1 particles on the rates of chemical reaction.

| No. of Blue particles | 50 | 100 | 150 |
|--------------------------------------|----|-----|-----|
| Time for five reactions to occur (s) | 5 | 2 | 0.5 |

The reaction is quickest with 150 number of blue particles.

(11) What do you think will be the effect of increase in temperature of reactants on the rates of chemical reaction?
The reaction will be quicker. *25 minutes at this stage.*

(12) In this part, you will still use the same screen as above. Use the temperature slider to investigate the effect of temperature variation on the rate of change of particle movement and

Appendix H2: SRL activity sheet 2

collision. Record how long it will take for five reaction products at 20°C to occur. Then repeat for 40°C and 60°C. Please keep the numbers of reactant 1 and 2 constant. Record your observations in Table 2 below.

Table 2: Effect of change in temperature on the rates of chemical reaction.

| Temperature (°C) | 20 | 40 | 60 |
|----------------------------|-----|-----|------|
| Time for five reactions(s) | 0.5 | 0.3 | 0.15 |

Explain your results:

The higher the temperature, the quicker the reaction.

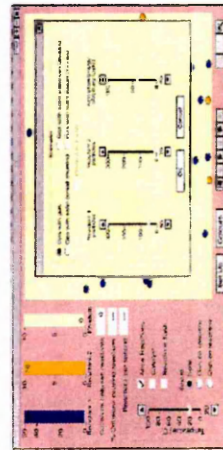
If you have any questions at this stage, please write them down in the space below.

- (1) _____
- (2) _____

(13) What do you think will happen to rates of chemical reaction if the activation energy is lowered?

It will slow down.

(14) In this last part, you will use the simulation to investigate the effect of changing activation energy on the rate of reactions. Again, use the "Setup up" button to set the number of particles for reactant 1 to 50 while that of reactant 2 is set to 10. Set the activation energy level to 40 and click OK. Your screen at this stage should look like the one below.



Appendix H3: SLR activity sheet 3

(15) Run the simulation by clicking on play button. Take note of the time spent for 10 reaction products to be formed. Then repeat for 50 and 60 levels of activation energy. Enter your results into Table 3 below

Table 3: Effect of changes in the activation energy of reactants on the rates of chemical reaction.

| Activation energy level | Time used for 10 reactions |
|-------------------------|----------------------------|
| 40 | 12 secs |
| 50 | 8 secs |
| 60 | 5 secs |

Remember to raise your hand if you like help with anything please.

(16) What do you think is the role of activation energy in the rate of a chemical reaction?

to slow down the rate of chemical reactions.


(17) Mention one factor that could help lower activation energy of a chemical reaction.

(1) changing temperature.

Are there any concepts that were not clear to you during the activity? Please write them here.

- (1) I don't understand any of it.
- (2) _____

Appendix H4: SRL activity sheet 4

- (4) Select "Reactions flash" box and click on the play button  to start the simulation. Observe carefully how the particles are colliding together.

What do you think happens when there is a flash? a reaction is made

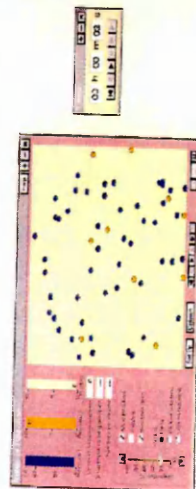
Did you notice any change in the colour of the particles?

What was the colour change? More black

How many flashes did you notice? 10

Did you notice any collision when there was no flash? Yes but hardly any
Therefore, we can say that for a reaction to occur the particles must collide with enough power & force





- (5) Now we need to take note of how long it will take for five reactions to occur at different concentration and temperature. Get the timer out by clicking on the tools icons located by the left hand side tool bar and then click on timer from the list. Your screen will be similar to the one below



Please make use of the timer provided in the tools section.

- (6) What do you think will be the effect of increase in concentration of reactant1 in the programme on the rates of chemical reaction?

It takes more time to react and then it stops after reactant 2 has gone 5/2

- (7) Use the "Setup" button  to set the programme to 50 reactants 1 and 10 reactant 2 particles. Click on play button  to run the simulation and then on the timer's play button  immediately. Use the product column next to reactant 1 and 2 to watch out for when five reaction products will be formed. Click on the timer's stop button  and record the time

Appendix H5: Non-SRL activity sheet1 1

taken for five reaction products to have formed in Table 1 below. Again, click on the "Set Up" button and increase the concentration of reactant 1 particles to 100 and then record how long it takes for five products to have formed. Record your answer in Table 1. Repeat the procedure with 150 reactant 1 particles and record the time for five reaction products to have formed.

Table 1: Effect of concentration of reactant 1 particles on the rates of chemical reaction.

| No. of Blue particles | 50 | 100 | 150 |
|--------------------------------------|----|-----|-----|
| Time for five reactions to occur (s) | | | |

Please enter your results under the correct columns.

The reaction is quickest with 150 number of blue particles.

- (8) What do you think will be the effect of increase in temperature of reactants on the rates of chemical reaction?


- (9) In this part, you will still use the same screen as above. Use the temperature slider to investigate the effect of temperature variation on the rate of change of particle movement and collision. Record how long it will take for five reaction products at 20°C to occur. Then repeat for 40°C and 60°C. Please keep the numbers of reactant 1 and 2 constant. Record your observations in Table 2 below.

Table 2: Effect of change in temperature on the rates of chemical reaction.

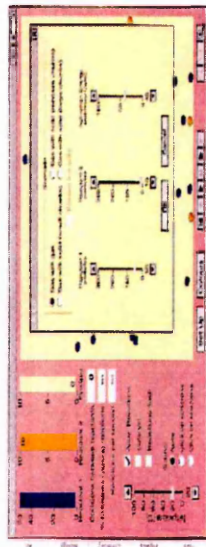
| Temperature (°C) | 20 | 40 | 60 |
|----------------------------|----|----|----|
| Time for five reactions(s) | | | |

Explain your results:

- (10) What do you think will happen to rates of chemical reaction if the activation energy is lowered?

- (11) In this last part, you will use the simulation to investigate the effect of changing activation energy on the rate of reactions. Again, use the "Setup up" button  to set the number of particles for reactant 1 to 50 while that of reactant 2 is set to 10. Set the activation energy level to 40 and click OK. Your screen at this stage should look like the one below.

Appendix H6: Non-SRL activity sheet 2




(12) Run the simulation by clicking on play button  Take note of the time spent for 10 reaction molecules to be formed. Then repeat for 50 and 60 levels of activation energy. Enter your results into Table 3 below

Table 3: Effect of changes in the activation energy of reactants on the rates of chemical reaction.

| Activation energy level | Time used for 10 reactions. |
|-------------------------|-----------------------------|
| 40 | |
| 50 | |
| 60 | |

Please record your observations on activation energy in this table.

(13) How will you explain the role of activation energy in the rates of chemical reaction. ?

(14) Mention one factor that could help lower activation energy of a chemical reaction

APPENDIX I: Observational Analysis

Appendix II: Observation, descriptions, and examples of the variables used to code students' self-regulatory behaviour in the two groups

| Observed Self-regulated learning Behaviour | Description | Example in SRL-prompted condition | Example in Non-SRL-prompted condition |
|---|---|---|---|
| Planning: Goals and sub-goals setting, Prior knowledge activation | Planning involves managing the whole leaning process. Students were expected to state what they think they will achieve at the end of the lesson. Activate their prior knowledge by linking the present task with what they have already known. | Students picked up their pens to write on the activity sheets after the instruction was read out to the whole class. | Spent time on the different colours of the molecule in the simulation and didn't settle down on the task on the activity sheet on time. |
| Skimming | This is a strategy that helps student in planning their learning in any given task. Students will go through the whole task at a go in order to plan how to carry out the task. | Observer noticed students going through all the pages of the activity sheet. | Students were on the front page of the activity sheets for a long time. |
| Taking note | Filling the gaps on the activity sheet after using the simulation learning environment. | A lot of students filled the gaps on the activity sheets. | Few students filled the gaps on the activity sheets. |
| Control of context | Making use of all the features in the rates of reaction simulation learning environment as well as the designed activity sheets. | Students followed the step by step instructions on their activity sheets and clicked on the correct buttons in order to perform the task. | Students were trying the carryout the task randomly, they kept on pressing different buttons in order to find their way round the learning context. |
| Help-seeking behaviour | Students seek assistance from tutor, researcher and peer regarding the adequateness of his or her | Requested for help from the science teacher and the researcher. | None of the students requested for help. |

| | | | |
|-----------------|---|--|-------------------------------------|
| | answer on the activity sheets or general use of the simulation environment. | | |
| Task difficulty | Students indicate whether the task is either easy or difficult and say whether using the computer-based simulation environment is more difficult than using a book. | Not too bad, it is better than sitting down with science book. | Harder than reading a science book. |
| Interest | Students have a certain level of interest in the given task or in the content domain of the task. | Interesting. | Very boring. |

Appendix I2: The three emerged categories

| | | |
|--|--|---|
| Understanding of the learning context: Planning, skimming, note taking, and control of context. | Task difficulty and demand: Help seeking behaviour and task difficulty. | Emotional level: Interest in the learning environment. |
|--|--|---|